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OPERATIVE DENTISTRY

OPERATIVE DENTISTRY

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FIFTH EDITION

LONDON
HENRY KIMPTON
25 Bloomsbury Way, W.C.1.

1945

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Reprinted November, 1946

Printed in the United States of America

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PREFACE TO FIFTH EDITION

In producing this book, the author wishes first to state that the cavity preparation for cohesive gold foil is that of our revered Dr. G. V. Black, since as yet nothing else has been developed to surpass its excellence.

The making and building of the inlay, amalgam, fused porcelain, and silicate, due to changed formulas and rapid development in the fields of endodontia and periodontia, have required radical changes in technic.

A large number of practicing dentists and teachers in our colleges have become more or less interested in clinical and correlated research, assisted by the Bureau of Standards, at Washington.

There seems to be a more general understanding that good enough is not good, and that knowledge enough is the beginning of ignorance and is to miss the dawn of tomorrow's advancement.

The author again acknowledges the assistance of his wife and partner, M. M. Davis, D.M.D., whose helpful hand has ever been extended when he seemed to falter.

W. C. D.

Lincoln, Nebraska

PREFACE TO FIRST EDITION

In the preparation of this textbook it has been the author's aim to meet a demand in dental college work for a treatise on operative dentistry which is sufficiently condensed to enable the student to master its contents in the comparatively short college terms at his disposal.

The subject matter selected is that which is generally taught by the instructor styled as ''Professor of Operative Dentistry.''

From a study of these teachers' courses of instruction it would seem that the definition of Operative Dentistry as commonly used today would be ''That branch of dentistry which treats of the mechanical procedures performed within the oral cavity looking to the salvage of the teeth.''

However, it has seemed wise in several instances to go beyond the exact limitations of this definition to get a better correlation of subjects.

The arrangement of the subject matter is different from that usually found, but is in accordance with the usual line of progress, of dental students.

The author claims little originality in the essentials presented, having gleaned the facts from the writings, teachings and utterances of our greatest educators.

The ''quiz-explanation'' method of teaching is the one most in vogue in the leading universities as productive of the most work on the part of the classes taught, and at the same time giving the tutor more freedom for the expression of opinions to give individuality to his course of instruction.

An effort has been made to so publish the ''Essentials of Operative Dentistry'' that it would serve as a foundation for this quiz course as well as be suggestive to the teacher for a more full explanation, and, at the same time, encourage the student to extend his studies to more voluminous reference books, when time would permit for an explanation in greater detail.

The author is much indebted to his colaborer, partner and wife, Mattie M. Davis, D.M.D., for valuable assistance in connection with the publication of this volume.

W. C. D.

CONTENTS

CHAPTER I PAGE

EXAMINATION AND DIAGNOSIS - - - - - - - - - - - - - - - 17

CHAPTER II

THE ALLEVIATION AND PREVENTION OF ODONTALGIA - - - - - - - - 23

CHAPTER III

PREVENTIVE DENTISTRY - - - - - - - - - - - - - - - - 28

CHAPTER IV

PROPHYLACTIC TREATMENT OF THE MOUTH - - - - - - - - - - 34

CHAPTER V

INSTRUMENT NOMENCLATURE - - - - - - - - - - - - - - 40

CHAPTER VI

CAVITY NOMENCLATURE - - - - - - - - - - - - - - - - 43

CHAPTER VII

TREATMENT OF HYPERSENSITIVE DENTINE - - - - - - - - - - - 50

CHAPTER VIII

CAVITY PREPARATION (GENERAL CONSIDERATIONS) - - - - - - - - 58

CHAPTER IX

GAINING ACCESS - - - - - - - - - - - - - - - - - - 59

CHAPTER X

OUTLINE FORM - - - - - - - - - - - - - - - - - - 61

CHAPTER XI

RESISTANCE FORM - - - - - - - - - - - - - - - - - 65

CHAPTER XII

RETENTION FORM - - - - - - - - - - - - - - - - - 67

CHAPTER XIII

PAGE
CONVENIENCE FORM - - - - - - - - - - - - - - - - - 68

CHAPTER XIV

REMOVAL OF REMAINING CARIOUS DENTINE—FINISHING ENAMEL WALLS—TOILET OF THE CAVITY - - - - - - - - - - - - - - - 69

CHAPTER XV

MANAGEMENT OF PIT AND FISSURE CAVITIES (CLASS ONE) - - - - - - 72

CHAPTER XVI

MANAGEMENT OF PIT AND FISSURE CAVITIES (CLASS ONE, CONCLUDED) - - 75

CHAPTER XVII

MANAGEMENT OF PROXIMAL CAVITIES IN BICUSPIDS AND MOLARS (CLASS TWO) 80

CHAPTER XVIII

LARGE PROXIMAL CAVITIES ENDANGERING THE PULP (CLASS TWO, CONCLUDED) - - - - - - - - - - - - - - - - - - 86

CHAPTER XIX

MANAGEMENT OF PROXIMAL CAVITIES IN INCISORS AND CUSPIDS NOT INVOLVING THE ANGLE (CLASS THREE) - - - - - - - - - - - - 92

CHAPTER XX

MANAGEMENT OF PROXIMAL CAVITIES IN INCISORS INVOLVING THE ANGLE (CLASS FOUR) - - - - - - - - - - - - - - - - - - 97

CHAPTER XXI

MANAGEMENT OF CAVITIES IN THE GINGIVAL THIRD (CLASS FIVE) - - - - 110

CHAPTER XXII

PAGE
MANAGEMENT OF ABRADED SURFACES. OCCLUSAL AND INCISAL (CLASS SIX) 113

CHAPTER XXIII

EXCLUSION OF MOISTURE - - - - - - - - - - - - - - - - 115

CHAPTER XXIV

MANIPULATION OF COHESIVE GOLD IN THE MAKING OF A FILLING - - - - 122

CHAPTER XXV

MANIPULATION OF COHESIVE GOLD IN THE MAKING OF FILLINGS BY CLASSES - 127

CHAPTER XXVI

FINISHING GOLD FILLINGS - - - - - - - - - - - - - - - 134

CHAPTER XXVII

SILICATE FILLING - - - - - - - - - - - - - - - - - 136

CHAPTER XXVIII

FUSED PORCELAIN FILLING. CAVITY PREPARATION - - - - - - - - 154

CHAPTER XXIX

FUSED PORCELAIN FILLING. CERAMIC TECHNIC FOR FILLINGS AND JACKET CROWNS - - - - - - - - - - - - - - - - - - - 159

CHAPTER XXX

CAVITY PREPARATION FOR GOLD INLAYS - - - - - - - - - - - 183

CHAPTER XXXI

THE MAKING AND SETTING OF A GOLD INLAY - - - - - - - - - - 195

CHAPTER XXXII

AMALGAM FILLING - - - - - - - - - - - - - - - - - 208

CHAPTER XXXIII

PAGE
The Use of Cements in Filling Teeth 251

CHAPTER XXXIV

Combination Fillings 258

CHAPTER XXXV

Periodontoclasia 262

CHAPTER XXXVI

Endodontia 293

CHAPTER XXXVII

Protection of the Vital Pulp 324

CHAPTER XXXVIII

Pulpectomy With Anesthesia 329

CHAPTER XXXIX

Partial Pulpectomy, Unavoidable or Accidental 334

CHAPTER XL

Partial Pulpectomy, Intentional (or Amputation) 353

CHAPTER XLI

Pulp Putrescence, Simple 360

CHAPTER XLII

Pulp Putrescence, Complicated, Acute, With and Without Fistula 368

CHAPTER XLIII

PAGE
Pulp Putrescence, Complicated, Chronic, With and Without Fistula 373

CHAPTER XLIV

The Drugless Management of Putrescent Pulp Canals - - - - - - 379

CHAPTER XLV

Correcting Previous Pulp Canal Surgery - - - - - - - - - - - 386

CHAPTER XLVI

The Filling of Pulp Canals (Mechanical) - - - - - - - - - 389

CHAPTER XLVII

Apicoectomy and Curettement - - - - - - - - - - - - - 402

CHAPTER XLVIII

Endodontia for Children's Deciduous and Permanent Teeth - - - - 408

CHAPTER XLIX

Prognosis in Endodontia - - - - - - - - - - - - - - - 410

CHAPTER L

Review of Dental Histology - - - - - - - - - - - - - 416

OPERATIVE DENTISTRY

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CHAPTER I

EXAMINATION AND DIAGNOSIS

A complete and thorough oral examination should be given early in our contact with a patient and periodically thereafter if the best service is to be rendered. Because of hurried and incomplete examinations, many dentists leave undone more dentistry than they do for the patient.

Pit and fissure cavities are allowed to remain. Proximal cavities are not detected nor are faulty gingival margins of fillings. Traumatic occlusion is ignored. Nothing is said about the treatment of gingivitis and subdental pathology. Teeth with imperfect canal operations are not even looked for.

Destructive caries is allowed to run its ravaging course with no suggestion that diet may be at fault. Children are allowed to pass to adult life with little thought of the irregular teeth presented.

Equipment.—The complete and modern equipment for the practice of dentistry is much more extensive than in former years. Advancing science has added its changes in all lines of human endeavor. Dentistry offers an increased and more efficient equipment which makes for greater service to the public.

Dental Chair.—The dental chair should be modern and adjustable to the comfort of each individual patient. It should be free from dust and have clean linen.

Office and personal linen should be clean. The dentist should wash his hands in running water in the presence or hearing of the patient.

Instruments Required.—Very few instruments should be in view of the patient as these may remind him of former experiences not altogether pleasant.

Mouth Mirror.—There should be an uninjured mouth mirror for light reflections and to obtain posterior views.

Explorer.—It is well to have several explorers to detect defects in enamel, loss of tooth substance through decay or fracture, and defective margins about fillings.

Cotton pliers should be used to hold cotton balls with which to wipe clean and dry the surfaces of teeth and gums. This is of particular advantage in the inspection of Class Five cavities often too sensitive to permit the use of an instrument.

Waxed Floss Silk.—By the use of floss silk we may cleanse the surfaces of the teeth and secure a deeper view into the proximal surfaces. In case the surface of either tooth has been roughened or cupped by beginning caries, it will show by catching or cutting the fibers of the thread.

Chip-Blower.—The chip-blower is of service in rendering surfaces dry and in subjecting individual teeth to the currents of cold or hot air, and is valuable in testing for vital pulp involvements.

Water Syringe.—A water syringe is important as an easy and sure means of subjecting a tooth to the extremes of temperature in dealing with suspected pulp lesions.

The Mechanical Separator.—The mechanical separator is of service to gain a little additional space for inspection in considering the proximal surfaces of the anterior teeth.

Electric Mouth Lamp.—The electric mouth lamp is of service in reflecting shadows through the proximal spaces and in transillumination when considering pulpless teeth or an approximating sinus. There should be a dark room in connection with the office for this examination by transillumination.

Electric Current.—An attenuated and controlled electric current with suitable contacting terminals should be part of each office equipment, to detect the presence and vitality of pulp tissue. This will check up on the results of the thermal tests and radiographs.

X-ray Equipment.—Full x-ray and dark room equipment is indispensable for the successful practice of modern dentistry. It is the "third eye" and doubles efficiency when considering many operative procedures, such as tooth extraction, detection of proximal cavities and defective cavofilling margins, previous dentistry in pulp canals, the condition of the subdental tissues, and periodical checkup on our own dentistry in particular.

Charts.—Most dentists do, and all should, keep as complete a chart system as possible of their patients. The completeness and extent of the charting will vary with the patient and the object which prompts examination. In the case of simple decay of the teeth the ordinary mouth chart will be sufficient. Whereas, when considering the relation of tooth lesions to a presented general systemic disorder, the charting should cover a very much broader field, which will be considered in a subsequent chapter.

First Requests of the Patient.—The patient has called for a definite purpose, and the dentist should give attention to the patient's first requests and comply with them. If the patient is or has been in pain, this should be relieved as soon as possible; the treatment for this is covered in detail in Chapter II. If the patient is not specific in his requests early in the visit, it is well to ask leading questions. While giving attention to specific requests, the dentist should note the probable care the mouth has received, the amount and character of the dental work in place as well as the probable date it was done, and the health, age, and probable habits of the patient. In case the patient is one of the dentist's former clients, it is well to have at hand his mouth charts and x-rays, which should give in detail the results of previous visits. Such observations will assist in answering the important questions regarding additional services.

Following a Complete Examination.—After a thorough and complete examination the dentist is in position to advise a patient intelligently as to his dental needs. Without such complete examination the dentist may be overlooking needed dentistry which would cut short processes destructive to tooth substance or subdental structures which may later be the cause of the loss of teeth, even the premature loss of the entire dentures.

Legal Liability.—A dentist, when appealed to, is legally as well as morally bound to respond with a complete and comprehensive examination and diagnosis. Failing in this, he may render himself legally liable. The courts have so ruled in medical malpractice suits.

Diagnosis.—Here is the parting of the ways even though each dentist has made a thorough examination.

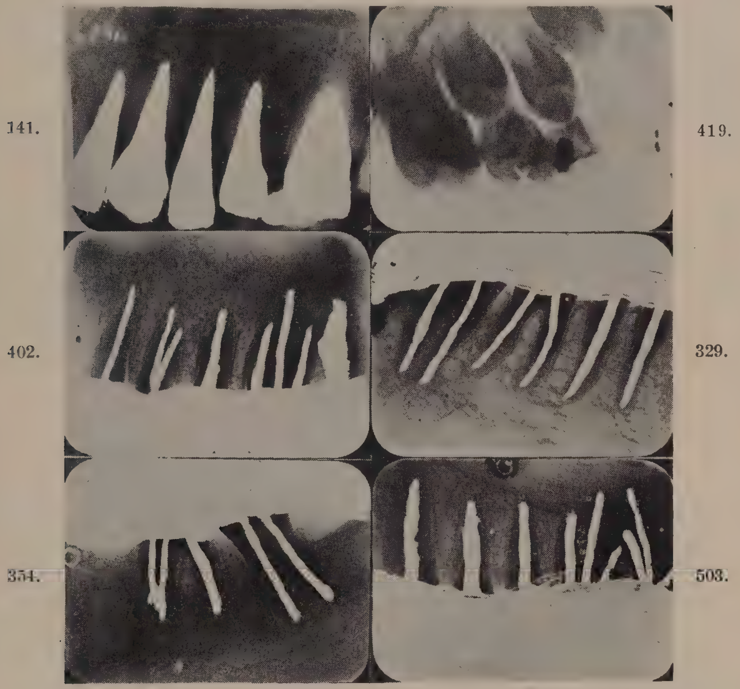

Fig. 1.—Covered dentistry. Can you read the pathology or must you see the previous dentistry? Case number by the side of each refers to the uncovered picture in the final pages of this book.

Intensive study and activity restricted to any single line of human endeavor narrows a man's horizon and dwarfs his conception of the importance of the labors of others outside his own restricted field.

Some of our dental specialists have assisted in the advancement of operative dentistry by increasing the life service of the organs of mastication to the benefit of the public.

Many others, however, because of the lack of a true perspective, have so far departed from sound practice as to advise carelessly the unnecessary loss of many useful teeth, totally ignorant of the possibilities of such cases in the hands of the general practitioner or under the care of a specialist in some other division.

Let not the orthodontist see irregularities in every mouth.

Let not the prosthodontist love too dearly the artificial.

Let not the periodontist or endodontist think that all affected teeth should be salvaged.

Let not the exodontist extract teeth indiscriminately.

Let not the doctrine of the "hundred percenter" be accepted when all but two of the American dental colleges are teaching and advising the salvage of the pulpless teeth as general practice.

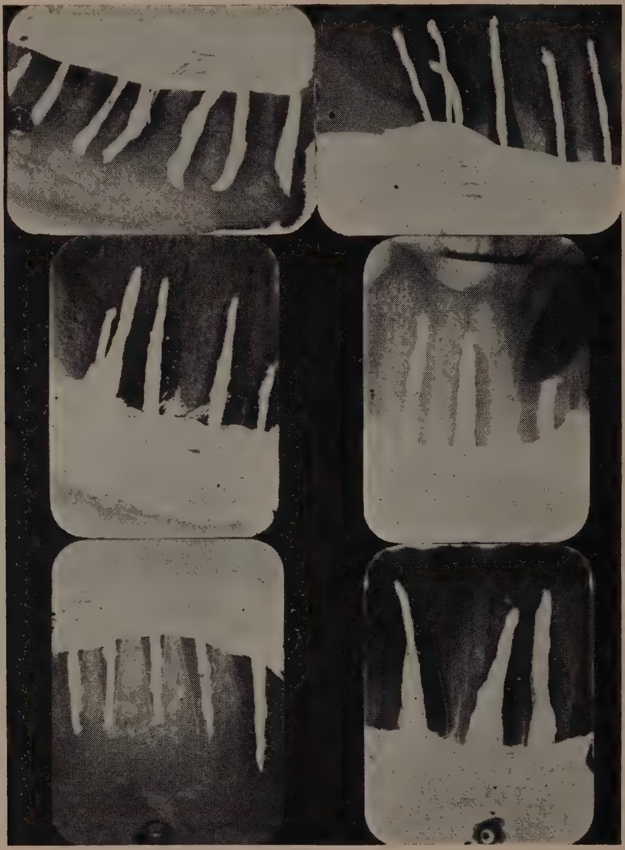

Fig. 2.—Covered dentistry. Case number by the side of each refers to the uncovered picture in the final pages of this book.

Before dismissing the subject of diagnosis, a little mental exercise for the reader might be well.

Some twenty-five years ago the author wondered if he was not reading the dentistry he saw in the x-rays rather than the condition of the subdental tissues, the periodontium in particular.

We felt reasonably sure that other physicians and dentists who sought to advise us were guilty of that error. So for a time we required the students in the college clinic to cover all x-rays brought to our office for reading, so that it was impossible to see any dental work that might or might not exist.

At once we were "at sea." We could not see that which had been the foundation of our diagnosis, i.e., previous dentistry. We then passed some of these on to outspoken physicians and dentists, at the same time (1919) publishing the tests.

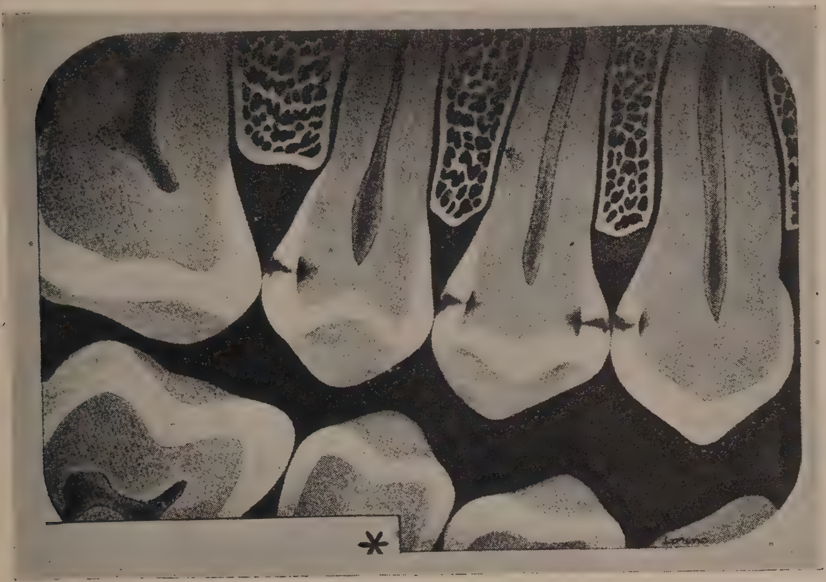

Fig. 3.—Showing a case in which previous dentistry plays no part in the diagnosis. The lack of dentistry is very frequently missed by the diagnostician. (Courtesy of the Cook-Wait Laboratory, 170 Varick St., New York, N. Y.)

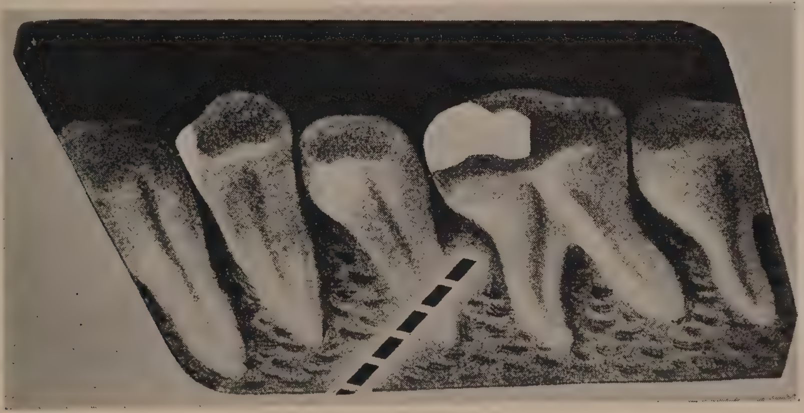

Fig. 4.—Showing advancing periodontoclasia, very possibly due to a diet deficiency and indicating the need for vitamin therapy. Most causes of periodontoclasia are from a general systemic disorder, in this case assisted by faulty contacts. Pathology here is easily read without seeing previous dentistry. (Courtesy of Benefax, The Anacin Co., Distributors, Jersey City, N. J.)

Very few radiographers know very much about the x-ray unless they can see previous dentistry in each tooth. Sorry, but that means the author and it means you as well. Try it.

Several covered x-rays follow. The same x-rays are uncovered at the end of this book. See what you can do with your diagnosis and then give your dictatorial brother some diagnostic calisthenics. It is hard schooling but we all need it.

Get your physicians and colleagues in the habit of reading pathology about the teeth, the periodontium in particular. Most of us read the previous dentistry but are ''at sea'' if that is shut out of the picture.

Summary

We have pretty well covered what constitutes a thorough examination of the oral cavity mechanically, electrically, and roentgenologically.

As to diagnosis and recommendations, there have been, are now, and always will be, diverse conclusions depending on the ability and skill of the dentist and what is paramount in his mind.

CHAPTER II

THE ALLEVIATION AND PREVENTION OF ODONTALGIA

Cause of First Visit.—In the majority of cases the primary visit to the dentist is in response to some form of oral pain or discomfort more or less severe. Giving the patient relief from this pain or discomfort is of first importance to both patient and operator and should be of major consideration at the first sitting.

Diagnosis.—Determination of the cause of pain in any part of the body is necessary if permanent relief is to result from treatment. The administration of an anodyne or anesthetic is only a temporary gesture. Their exhibition alone is an admission that we are powerless to remove the immediate cause of the pain or that the cause has not yet been determined.

Symptomatology.—The first statements of the patient giving the syndrome should receive strict attention, as he is quite sure to give the symptoms in the order of their prominence, which are most likely pathognomonic. He should be quizzed further to bring out the accessory symptoms which have a bearing on the case. The patient is right as to symptoms, yet frequently wrong as to location and cause. In some cases the symptoms are so varied and overlapping that the diagnosis must be made by the process of elimination. Pain and other symptoms are the effects and may result from two or more causes in close proximity, or even widely separated, requiring a studied and discriminating consideration.

Divisions of Dental Pains.—There are three divisions of dental pains: those arising from lesions of the pulp; those arising from lesions of the periodontal tissues; and neuralgia arising from the same general cause as other pains of the rheumatic group lesions.

Pulp Pains.—The abnormal response to thermal change is the one important symptom showing a pulp involvement. Added to this there may be increased pain upon assuming the recumbent position. When these are the only symptoms, the pulp is the only tissue involved. When sweets cause pain there is exposed vital dentine, relieved by a filling, temporary or permanent. In more advanced caries the pressure of food particles on the dentine, particularly when the pulp is nearly exposed, may cause pain of a temporary nature. Relief is secured by removing the foreign substance and filling the cavity.

When Cold Causes Pain.—If cold air or fluids cause a sharp shooting pain which comes on suddenly and passes off as soon as the tooth regains the body temperature, the pulp is in the stages of active hyperemia due to exposure through caries, cavity preparation, trauma, or it may be infection, in close proximity to the foramina.

Treatment for Pain in Active Hyperemia.—The treatment consists of removing the cause if possible and preventing its re-establishment, and in the use of anodynes and disinfectants. (See Chapter XXXVII, ''Protection of the Vital Pulp.'')

When Warmth Causes Pain.—If moderately warm fluids, as well as cold, cause pain, the pulp is in the initial stages of passive hyperemia or venous congestion, and as the congested condition progresses, we have the symptoms of increased pain upon lying down. Throbbing pain indicates a neuroparalysis of the vasoconstrictor nerve filaments of the blood vessels, permitting undue vascular dilation and pressure on the nerve trunks within the pulp tissue. The patient will generally answer ''yes'' to the question, ''Did your tooth begin aching about fifteen minutes after lying down?''

Treatment for Pain in Passive Hyperemia.—The treatment for relief of pain consists in removing the obstruction and producing a slight exposure and hemorrhage, and dressing the cavity with a sterilizing anodyne. Such pulps in mature teeth, however, may not regain normalcy. These are further considered in Chapter XXXVII.

When Cold Relieves Pain.—If warm or hot fluids cause pain, and cold relieves it as by holding cold water in the mouth, there exists a case of closed putrescence. This may have so far progressed that there is continual pain except when the tooth is bathed in cold water. Some part of the pulp has become necrotic and is being resolved into the end products, some of which are gaseous. The raising of the temperature expands these gasses, the pressure of which causes pain in the yet vital portion of the pulp, apex-wise from the seat of the primary lesion.

Treatment for Pain in Closed Putrescence.—The initial treatment consists of opening the pulp chamber and allowing the gas to escape together with any fluids which may be present. If slight hemorrhage results, so much the better. The saliva must be excluded and an application of a sterilizing anodyne made for a few hours. For subsequent treatment see Chapters XLII and XLIII on ''Pulp Putrescence.''

When Pressure on Tooth Causes Pain.—When a tooth is sore to ''bite on'' and percussion causes pain, the periodontal tissues are diseased. The effect may be so slight as to show only dullness in the percussion note when the tooth is tapped with the end of a steel instrument, there may be, however, extensive complications and no pain.

Treatment for Pain in Active Complicated Putrescence.—Drainage from the apical region is the most essential thing for relief. This drainage may be via the pulp canal to exit, or from an opening through the labial or buccal plate at apex, or both. In addition to, or before, surgery, the judicious use of a revulsive anodyne over buccal or labial roots is advised. Suggest aconite and iodine. For permanent treatment see Chapter XLII on ''Pulp Putrescence, Complicated, Acute.''

Pain Following Tooth Extraction.—Postextraction pain is generally augmented by infection and the amount of contused tissue resulting from the operation. In infected cases where the subdental pathologic tissue has been allowed to remain, and in difficult cases where there has been left more or less contused tissue, severe afterpain is frequent. In the infected cases the resultant blood clot may be disorganized early, particularly if the tissue has not been sutured. In cases of much contusion of either hard or soft tissue, there is liable to be sloughing. Again, some overenthusiastic beginner may pack a socket or bony cavity in the mouth with gauze, which in a few minutes is a dirty rag. Any one of the above may cause what is known as a "dry socket," a very painful condition sometimes lasting for days. Poulticing the face is much condemned as such practice leads to external pointing.

Treatment for "Dry Socket" Pain.—Care in the proper removal of subdental pathologic tissue, caution as to contusion, the exercise of good surgery, and the proper closing of wounds will seldom make treatment necessary. When a patient with this condition comes to us, however, it is best to spray the socket thoroughly with a warm antiseptic solution. Render the socket reasonably dry and touch all denuded bone surfaces with a saturated solution of the crystals of iodine and tincture of aconite, while protecting the surfaces of nearby tissue. Render dry again and inject into the socket warm petroleum jelly into which has been mixed about 10 per cent each, glycerin, bismuth subnitrate, chloretone, and thymol iodine. The latter is 43 per cent iodine. Pain will generally cease after the first treatment. In persistent cases put the patient on an antacid diet, including a liberal amount of orange juice three times a day. Internal medication is often advisable. Specific echinacea in doses of 5 to 30 drops between meals will hasten relief in most infectious processes. Immediate relief may be secured through the administration of anodyne tablets. Avoid all forms of gauze packing in the mouth. A secondary curettage is ill advised unless drainage is shut off and extensive necrosis is threatened.

Facial Neuralgia.—Distressing pains about the face which are expressed through the trifacial nerve may be of local dental origin or may be the expression of certain general diseases. There are also cases where the cause is not apparent.

Neuralgia of Dental Origin.—In addition to the pulp lesions, simple and complicated, already considered in this chapter, continued and intermittent pains about the face may result from the formation of pulp nodules, hypercementosis, calcific deposits on roots, infection about the roots, large contour restorations approaching a vital pulp (expansion of our modern amalgam), too tight plugging of fillings and inlays causing undue expansion of the dentine walls, exposed dentine or cementum, and impacted teeth. The treatment is both medical and surgical. Medical treatment may be either general or local, or both.

General treatment, or internal medication, is called for many times but should be for relief only until the cause of the pain has been ascertained. If the pain is from dental origin, the administration of some of the compounds containing **antipyrine, acetanilid, codeine,** or **phenacetin** is indicated preferably with the advice of the patient's physician.

Local Treatment.—The local treatment given will be of benefit in relieving pain only after a correct diagnosis as to the cause has been made.

Surgical Treatment.—Facial neuralgia may result from causes relieved only by the removal of irritants about the teeth. When the cause does not seem to be of oral origin, collaboration with the family physician is advised.

Tic douloureux is a condition of pain frequently resulting from a chronic irritation of the fifth cranial nerve, and patients deserve much sympathy as little can be done medically or surgically in the way of permanent relief. At this time the injection of 75 per cent alcohol in the foramen of the affected nerve trunk seems to be the best treatment. The injection should carry about a 2 per cent solution of novocain, without suprarenin, and should be about 5 c.c. in quantity. This results in a rather disagreeable prolonged anesthesia and paralysis of the parts supplied by both sensory and motor nerves. It is regrettable that after some weeks or months the distressing condition returns and calls for a repetition of the treatment.

Rheumatic Neuralgia.—When neuralgia is of a rheumatic nature, it is generally of streptococcal origin. It may be of dental origin or from a source remote from the mouth. Relief is secured only by getting rid of the infectious processes and is best accomplished through cooperation with other specialists, each working in his respective field and avoiding the appearance of dictation. Happy is the dentist associated with other specialists who appreciate the advanced position of dental education at this time. The extraction of teeth is not the only answer to dental pains and oral infections.

Pain From Dental Operations.—Modern dentistry has so advanced in the use of anodynes and anesthetics, both local and general, that there need be no longer any dread of pain during dental operations. A dentist who causes his patients much pain in performing dental operations is either careless or behind in his knowledge of the published facts. In this day a successful dental practice can be built or maintained only when the operator shields his patients from practically all pain incident to dental operations.

General anesthetics have long been resorted to in major and minor operations. Of these we mention nitrous oxide gas with oxygen, somnoform, chloroform, ether, and some of their combinations. These are exhibited in neurotic cases, in cases where there is widespread or complicating infection, and when there are known contraindications to the use of novocain.

Local Anesthetics.—Since the introduction of the comparatively safe formulas containing novocain, general anesthetics have been less used. By the use of some one of these formulas in the so-called ''nerve block'' and infiltration methods in noninfectious cases, the operator is enabled to eliminate the pain of most dental operations. These methods are most useful in such operations as the removal of teeth regardless of their location, the opening of the maxillary sinus, cavity preparation in teeth, pulp amputation, pulpectomy, apicoectomy, the establishing of buccal or labial drainage in cases of complicated putrescence, the lancing of alveolar abscesses, and curettement and surgery incident to the treatment of periodontoclasia.

Pain of Cavity Preparation.—In addition to the use of novocain, and where it is desirable to avoid its use, much may be accomplished through the following means: the topical application of remedies in the cavity; extraction of moisture from the tubuli by using alcohol in rather generous quantities in the cavity and later evaporating it with warm air; operation on desiccated dentine; the destruction of the protoplasm through the use of phenol; the use of sharp burs and instruments, so using burs as not to heat them above body temperature; so placing retention as to avoid sensitive places; sometimes avoiding retention form altogether and relying on cement to make a filling adhesive; cutting from, rather than toward, the pulp in cavity preparation; maintaining a low temperature with a stream of air or water much below the body temperature; and other methods of proved value.

Summary

A patient who has pain within or near the mouth will greet you with the statement, "I have a toothache."

Which of the three divisions is responsible for the pain must be decided. Is the cause from the tooth pulp or the periodontium, or does it belong to the rheumatic group lesions? The condition is attacked accordingly.

Each of these causes is fully treated in this chapter.

CHAPTER III

PREVENTIVE DENTISTRY

Preventive dentistry is of increasing importance and bears the same relationship to a worthy dental practice that preventive medicine does to the practice of medicine.

The prevention of disease and destruction of any of the tissues or organic functions of the human body should be our first thought with adult patients and particularly so with young children.

The securing and maintaining of a healthy mouth necessitates the consideration of diet, oral cleanliness, gingival irritants, tooth restorations, correction of traumatic occlusion, and education of the dentist's clientele in oral hygiene.

Diet.—Preventive dentistry has its beginning with the proper diet of the pregnant mother for the benefit of the child in utero. Defective teeth as to anatomic faults and qualitative deficiencies at time of eruption is a local expression of a general deficiency frequently caused by an unbalanced diet.

Much research has been done and the results published, so that all dentists should be able to instruct their patients as to a proper diet.

We should secure the cooperation of both parents and children. Dental students in our several institutions should have the advantage of consulting their departments of pediatrics, and dental practitioners should seek the cooperation of the family physician or a specialist. After the teeth erupt, some of them decay and some do not. Some have periods of decay and periods of immunity in the same mouth and even in a given tooth, with approximately the same immediate environment as well as care. The answer may be found in a change of diet.

Many suitable diets for the child and the adult have been published and do not need to be repeated here. It cannot be too strongly emphasized, however, that the most important factor in preventive dentistry is a proper diet, as it closes the door to the attack of the agents of decay.

Oral Cleanliness.—The maintenance of a clean mouth prevents damage from the active agents of tooth decay. It simply means the early removal of all foreign substances such as food particles, the acids incident to food decomposition, bacteria, and their products.

Frequent brushing with soap will often remove the film which forms on the teeth and acts as a protection to the colonies of bacteria. Brushing will dislodge the bacteria and permit the dilution of the acids from fermenting food, and will render the enamel surfaces of the teeth bare to the protecting influence of the saliva.

Gingival Irritants.—Frequent brushing is also our only means of retarding or preventing the solidification of the lime salts precipitated in the mouth from the saliva, which, when incrusted upon the teeth, are known as tartar. The presence of this tartar at the gingival border is a mechanical irritant to the subgingival tissues and may result in their destruction.

Radiographic examination of the teeth and subdental structures periodically is doing much for preventive dentistry. Early detection of proximal decays, possible with the x-ray, saves much tooth substance and many tooth pulps. Early detection of bone dissolution, a rarefying osteitis, or a pathologic condensing osteitis gives to the experienced dentist early knowledge of the ravages of infection and tooth decay. They learn of overuse or disuse, malocclusion, and other enemies of healthy dental organs.

Periodic visits to the dentist for oral prophylactic care should be insisted upon. A full mouth x-ray examination should be made at intervals of not more than a year apart in the cases least liable to pyorrhea and much oftener in mouths showing gingival pathology and questionable pulp canal fillings.

Better service to the patient will result if the dentist calls him at regular intervals to remind him of his obligations to his mouth and teeth and thereby to his general health.

Fluorine.—Those interested in preventive dentistry are more or less familiar with the advent and progress of the studies relative to the effects of fluorine on the developing tooth, even following eruption.

Dr. Frederick S. McKay of the Colorado Springs Dental Society became interested early in this new-found fact, and was able to interest Dr. G. V. Black in 1908. We note that the first article in dental literature on this subject appeared in *Dental Cosmos,* in 1916, under the joint authorship of Dr. Black and Dr. McKay, entitled, ''Fluorine and Dental Health.''

Since that time, much has been done to develop a method to improve the dental organs as they develop in utero and during the first few years of life, and to keep them resistant to decay for a lifetime of service.

It has been accepted that fluorine as a constituent of enamel, dentine, and cementum is an absolute necessity, and a lessening of the amount causes an increase of the hazard of caries.

The method of supplying fluorine to our human needs seems to be of great interest in the studies of preventive dentistry. The feeding of a physiologically prepared calcium-phosphorus-fluorine as found in bone meal to the mother during gestation, the child (in baby foods), and the adult, is advocated as follows by Dr. Charles B. Branson of Lincoln, Nebraska, in the *Journal of the American Dental Association.**

> ''Accordingly, in such a complete and comprehensive mineral food supplement, this calcium-phosphorus-fluorine ration in a naturally balanced form may be readily ''fitted'' to the individual needs, in conformity with the scientific principles followed in the administration of drugs. . . .''
>
> ''I wish to propose herewith a fluorine-calcium-phosphorus therapy for the systemic control of dental caries, a therapy strictly in accordance with Nature, safe, efficient and practical—the use of prepared 'edible' bone in our diet.

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*Volume 31, Jan. 1, 1944.

"The fundamental value of bone as a food for combating dental caries can be appreciated only when the basic nature of such bone is fully revealed, together with the vital role it plays in the mineral nutrition of virtually all carnivorous creatures except civilized man himself. Gray gives the following analysis of the constituents of normal bone: organic matter, 33.30 per cent; calcium phosphate, 51.04 per cent; calcium carbonate, 11.30 per cent; calcium fluoride, 2 per cent; sodium salts, 1.20 per cent, and magnesium phosphate, 1.16 per cent.

"It will be noted that an appreciable amount of fluorine is found to be a basic constituent of normal bony tissue, apparently indispensable for normal construction and strength of not only the bones, but also the teeth, which are known to be essentially the same in mineral content as the other animal bone that we may use as a food. Recent analysis indicates that beef bone normally contains more than 350 parts per million of fluorine. Here is a veritable storehouse of this element for our use in the safest, physiologic form, already accompanied by calcium and phosphorus in a Nature-prescribed combination and 'balance' for a mineral food.

"Thus, a general consideration of the fluorine content of strictly normal bone provides a clear index as to the relative proportion which Nature itself prescribes, in combination with calcium and phosphorus salts, for meeting the needs of resistant teeth, as well as strong bones within the body. Where we have heretofore stressed the need for an adequate calcium-phosphorus supplement to the diet in proper ration and balance, it is apparent that we should consider the calcium-phosphorus-fluorine ratio in determining such supplement.

"Although scientists have lauded milk as a tooth and bone builder for the child particularly, because of its high calcium-phosphorus value, it is a well-known fact that such milk has largely proved a failure in protecting the teeth against decay thereafter, presumably owing to a lack of that calcium 'fixing' element, fluorine, which, when available as a calcium accompaniment, appears to render the teeth largely immune to caries. Whereas milk, as consumed, shows but 0.4 parts per million of that vital element fluorine, approximately 2½ quarts being required to provide 1 mg. of fluorine, but 3 gm. of normal bone is needed to supply this fluorine equivalent, which is now considered the basic unit required daily for preventing dental caries.

"Biologic studies clearly indicate that virtually no meat-eating creature except modern, civilized man depends on milk as a source of calcium after the 'weaning' stage, when they have completed their first dentition and are capable of ingesting the more solid types of food. From such weaning time, throughout adult life, it is a well-known fact that all such carnivora must obtain their calcium ration almost exclusively from the blood and bone of the animals utilized as food, particularly the bony structures in which Nature has stored the vital mineral elements in such concentrated form and in exact physiologic proportions.

"Notable among the bone-eating animals is the dog, to whom a bone ration is virtually indispensable for normal growth and well-being, as every dog owner will readily agree. Furthermore, among all such bone-eating creatures, soundness of teeth as well as bony framework is the rule rather than the exception, ostensibly owing to a considerable extent to that fluorine factor found so abundantly in bone, but which is so obviously lacking in the diet of the average civilized man today.

"The utilization of bone as a vital mineral food is nothing new to primitive people and to others of the older countries of the world. The fish-eating Indians and the Eskimos of the Pacific Northwest have long been accustomed to eating the softened fish bones, together with the flesh. By the Eskimo, such bones are recognized as an essential factor in the diet for replenishing the bony structures of their bodies. The teeth of such individuals are almost incomparable, as indicated by Price in his study of the teeth of primitive people throughout the world. In fish, as in the case of animals, the fluorine content of the bones is always high, being beyond 250 parts per million.

''In ancient Tibet, a recent report states, the most cherished gifts received by a new mother consisted of powdered yak bone and pigs knuckles, to aid in meeting the systemic demands for bone-building and tooth-protecting elements following the birth of a child. Thus, the natural instinctive wisdom of more primitive folk tends to direct them unerringly to the most abundant supply of calcium, phosphorus and fluorine available—the bony, animal parts.

''The unusual value of bone as a source of available calcium and phosphorus, together with their retention, is readily disclosed by a recent report from India, where calcium deficiency constitutes one of the most common defects in the prevailing diet of rice and fish. Metabolic studies with such rice-and-fish diets in which the bones were discarded showed that the subject suffered from a negative calcium balance. However, when 70 gm. of small whole fish (bones included) was added to the diet with its typical calcium deficiency, the dietary calcium was augmented by 577 mg. (average), of which calcium 70 per cent was retained The phosphorus content of the diet was also increased by an average of 673 mg., of which one half was retained. This calcium retention percentage is at least double the amount reported by Robinson, who states that only from 15 to 35 per cent of calcium is utilized by adults ordinarily.

''Wide personal observation and inquiry have disclosed the biologic fact that there appears to be a definite correlation between an unusually sound and resistant set of teeth and a dietetic history of a craving for and eating of all the softened ends of bones that were edible, such as the ends of chicken bones and spareribs, with all the 'gristly' parts of meat that could be readily masticated. Such correlation has been found to occur almost without exception in elderly persons who have retained their teeth until late in life, relatively free from caries. The same correlations have also appeared to hold true for younger persons, from adolescence on through the years; but the elderly, with their life-long freedom from caries, have given the most conclusive evidence.

''When it is considered that the 'edible' bone thus ingested contains up to 350 parts per million of fluorine or perhaps even more, in addition to a very high calcium and phosphorus content, it would require only about 3 or 4 gm. of such bone to provide 1 mg. of fluorine per day as a supplementary ration. This is the equivalent of the fluorine content of about 2½ quarts of milk, or of that contained in about 5 glasses of drinking water fortified with 1 part per million of fluorine, the approximate amount needed daily, according to estimates made, for rendering the teeth comparably immune to dental caries. Furthermore, the calcium-phosphorus analysis of bone indicates that 4 gm. of bone will provide almost as much of these vital mineral elements as is contained in 1 quart of milk, thus revealing its milk replacement value in the diet where the calcium-phosphorus level is low.

''. . . In this therapy, however, we are administering a safe and natural fluorine bearing food—a highly vitalized mineral food prescribed by Nature—instead of dealing with an uncertain inorganic chemical such as sodium fluoride represents.

''When the meager data relating to fluorine are pieced together, it appears obvious that any systemic fluorine therapy cannot be a complete success in dental caries control, without due consideration of that 'balancing' element, calcium, which neutralizes the toxic nature of fluorine through chemical union, thereby creating such highly resistant fluorinized calcium salts as can be found in caries-resistant enamel.

''Neither can a systemic calcium-phosphorus therapy alone offer any hope of dental caries control without consideration of that reciprocal, calcium-binding element, fluorine. Thus, as evidence of what a deficiency of the fluorine factor may do when an abundance of calcium and phosphorus is available, one may point to the failure of milk and the various synthetic calcium-phosphorus preparations to control dental caries when the fluorine element is lacking.

''With the calcium-phosphorus-fluorine therapy now available, balanced physiologically as well as chemically to meet the needs at hand, let us attack the dental caries problem at its systemic base, through working in direct harmony and cooperation with biologic principles and laws. Let us thus seek to wipe out, through simple and natural means, the most prevalent of all the diseases that afflict civilized humanity today, dental caries.

CONCLUSIONS

"The fundamental value of fluorine for protecting teeth against caries has been well established. Although the exact etiology of such protectiveness remains somewhat obscure, sufficient data are available to justify the judicious use of fluorine, particularly in combination with calcium and along Nature-prescribed lines. The calcium-fluorine-phosphorus combination as found in bone meets practical requirements in a safe and simple manner.

"In the final analysis of the dental caries problem, it might be stated that a decayed tooth is a starving tooth, starving for certain mineral elements of a protective nature which the saliva should normally supply, particularly calcium, phosphorus and fluorine. The saliva, in turn, must depend largely on an adequate systemic reserve of those essential minerals which are needed for tooth protection against oral acids, etc. In the absence of such systemic reserve, the salivary function must necessarily lose much of its neutralizing and remineralizing power, with dental caries tending to ensue thereafter.

"The storage of large amounts of fluorine combined with calcium and phosphorus in normal bone clearly indicates that such fluorine is an indispensable factor in the construction and stability of all bony tissues of the body. The relative proportions and combinations thus involved in normal bone construction provide a clear and definite 'index' to the approximate bodily requirements of such vital elements when ingested through food or drink.

"Nature appears to have ordained bone as well as flesh for food of virtually all meat-eating creatures including man, who seems to have largely failed to perceive its potential physiologic value in the modern civilized diet. The high state of animal nutrition relative to general body structure, bone development, soundness of teeth, etc., bears mute witness to the nutritional benefits which the balanced mineral elements in bone may thus import."

Topical Application.—Immediately following this paper in the *Journal of the American Dental Association* are two by Dr. Basil G. Bibby, Dean of Tufts College Dental School, giving the results of the topical application of fluorine to the teeth, and appending a bibliography of forty authors.

The use of fluorine is twofold, it seems to the author. The ingestion of calcium-phosphorus-fluorine by the gestating mother seems to have little or no effect on the developing fetus because little, if any, real bone is developed in the child till after birth.

In all probability there is a breaking-down of this combination, and the liberated fluorine is the cause of the spotted and discolored enamel.

Just following birth, however, there is a great demand for bone-building material, which, when available, results in much good to the teeth.

Following rapid growth when the bones and teeth are nearly or quite developed, there can be no repair to damaged enamel or dentine by oral ingestion of fluorine.

The checking of decay could then take place only by contact with solutions of that substance as found in drinking water in certain localities.

In conclusion, it would seem: First, that fluorine administered to mothers, as in aqueous solution, acts as an injury to the developing teeth of the fetus. Second, that administered to the growing child, it is of much benefit to the teeth. Third, that decay is retarded in already established caries when fluorine solutions as a mouth wash are brought in contact with the decayed area. Some of our cements and silicates now contain varying amounts of fluorine.

Summary

In 1888, when the author began the practice of dentistry, dental literature was replete with the studies of research workers seeking to discover some means by which tooth decay might be prevented, other than the hygienic care bestowed on the teeth by their owner. We are still searching and are not sure that the problem is any nearer solution than at that time.

Those who have studied the effects of diet and pabulum have won a minor victory.

The fluorine content of the teeth is at this time receiving attention.

CHAPTER IV

PROPHYLACTIC TREATMENT OF THE MOUTH

The importance of prophylactic treatment early in a series of visits to a dentist and at stated periods thereafter is second only to the relief of pain, the neglect of which jeopardizes the remaining tooth structures, the permanency of attempts to check the ravages of caries and disease, as well as the reputation of the operator's skill.

Lack of hygienic conditions about the teeth is the sole, immediate, and exciting cause of primary or secondary decay of the teeth, and many an operator of exceptional skill as to the making of fillings has failed from a disregard of these conditions. As much of the success of dental operations depends upon the care of the mouth by both dentist and patient in the way of prophylaxis, as upon the skill of the dentist as an operator. The making of a filling is but the repair of an injury and is only a temporary check to the progress of destruction if the primary cause of dissolution is to remain operative.

The subdental tissues are also diseased by a lack of prophylaxis to the extent, many times, of their entire loss, so that the teeth themselves are loosened and lost through a lack of structures to support them. The teeth so lost are many times yet undecayed, and, in the present-day advancement of dentistry, experienced operators are forced to consign more teeth to the forceps from the result of diseased conditions in the tissues surrounding them than from decay of the teeth themselves. If this be true, the dentist cannot ignore the importance of combating the agencies which bring it about.

The kinds of deposits upon the teeth are generally classified as salivary calculus, serumal calculus, green stain, and sordes.

The first two named are enemies to tissue about the teeth, while the last two are responsible for most of the destruction of the hard dental tissues by caries.

Composition of Salivary Calculus.—Mixed saliva contains in man an average of about 0.5 per cent solids. The calculus is precipitated into the mouth in a form of a finely divided calcoglobulin, which collects in masses upon any stationary object, close to the mouth of the gland ducts. The fresh deposit is very soft and greasy to feel when first deposited, but within twenty-four hours it begins to harden and increases in hardness up to the time of thirty or sixty days, when it has generally attained its full hardness and will break away from the stationary object in masses, showing distinct lines of fracture.

Lime Salts Held in Solution.—Calcium phosphate and magnesium phosphate are held in solution in the saliva, made possible by the presence of a little carbon dioxide.

Reasons for Precipitation.—When the saliva is discharged into the mouth, it is released from the normal blood pressure and some of the carbon dioxide escapes, which allows the calcium salts to be precipitated. The lactic acid which is continually formed in the mouth converts the mucus into a curd in which the calcium salts are entangled to harden into salivary calculus. This process is assisted by the presence of the oxygen taken into the mouth with the breath, which facilitates the liberation of the carbon dioxide in the process of oxidization.

Time of Deposits.—It would seem from the experiments of Dr. Black that the deposits of salivary calculus are paroxysmal and also that these periods of rapid deposit follow the ingestion of heavy meals. He thinks that these periods of excessive deposits come at a time when the blood is overcharged with pabulum.

Kind of Food.—It does not seem from his experiments that the kind of food has very much to do with these deposits. The more easily a food is digested, the more quickly following the meal will these deposits appear.

Habits of Patient.—It would seem that the habits of the patient have little to do in influencing the amount of these deposits. Those who live a life of physical exertion, however, which favors the using of heavy meals, have a greater tendency to deposits of tartar than those whose vocation would cause them to eat lightly.

Mouths Most Subject to the Deposit.—From our present understanding of this subject it would seem that the mouths most subject to the deposit of salivary calculus are found in the following individuals:

First, those who from constitutional reasons have a tendency to an abundance of carbon dioxide in the excretions and secretions. This condition may be brought about by great physical or mental activity, or where the skin, kidneys, or lungs, or all, are not performing their full functions. These are the principal eliminators of carbon dioxide. Such individuals are very liable to be troubled with precipitation within the gland and ducts through which their secretions are expelled, resulting in cystic, glandular, biliary or renal calculi.

Second, those individuals who either occasionally or habitually engorge heavy meals, the quantity of which is greater than that needed for growth or maintenance.

Third, those in whose mouths the amount of lactic acid is more than normal.

Fourth, public speakers and mouth breathers, whether awake or during sleep. The great amount of oxygen coming in contact with the saliva assists in the rapid liberation of the carbon dioxide and consequent rapid precipitation of the calcium salts.

Prevention of Salivary Deposits.—It would seem that salivary deposits can largely be prevented by stimulating the circulation, stimulating the elimination of carbon dioxide from the body, checking mouth breathing as much as possible, correcting overacidity of the mouth, limiting the amount of food taken into the stomach at each meal by more nearly equalizing the three daily meals to the needs of the body; also by so highly polishing the surfaces of the teeth upon which the deposit is precipitated as to facilitate the mechanical removal of the fresh deposits; and last but not least, by so instructing the patients in the mechanical features of the care of their teeth that in so far as possible all fresh deposits are removed before hardening takes place.

Serumal calculus is a calcic precipitate from the blood. The salts in solution in the blood as well as the stability of suspension depend materially upon the presence of a normal amount of carbon dioxide.

Serumal calculus is deposited beneath the gum tissue wherein there is a passive hyperemic condition or congestion. Here we have excessive tissue waste, lessened alkalinity of the blood, a liberation of the carbon dioxide, and consequent precipitation of the inorganic salts. By the recession of the gum after the formation of the serumal form of calculus, it may be exposed to view or mixed with the mass of salivary calculus.

Serumal calculus in appearance is of a much darker color than salivary calculus and of a harder consistency, and generally adheres to the surface of the tooth more tenaciously.

Serumal calculus is also found on unexposed portions of roots of teeth which approximate inflammatory exudates, or are bathed in escaping blood plasma associated with chronic conditions of the apical space. It also appears in other portions of the body, as about the joints subjected to chronic inflammations as well as in the glands continually gorged with blood.

The bulk of serumal calculus is comparatively small, owing to its formation in restricted spaces, and is generally found in small nodules, narrow bands, and thin scales, not always easy of detection or removal.

Stains upon the teeth are of varying degrees of shade in several colors and for cosmetic reasons stand for immediate removal when detected. The green stain found upon teeth, however, is so closely connected with the first stages of caries on surfaces so affected that it deserves special consideration.

Green stain is generally confined to the labial surfaces and particularly the gingival third of the anterior teeth. It is most freqlently found upon the teeth of children and may be seen upon either the deciduous or the permanent teeth. When it persists for a considerable time upon these surfaces of the permanent teeth, the enamel will be found to be etched by a dissolution of the cemental substance evidenced by the whitened surface.

The color is due to the bacteria present.

The injury to tooth substance is due to the acid which these bacteria produce.

The reason for their presence is the favorable place for lodgment afforded by the persistence of the cuticula dentis.

Sordes consists of a mixture of food, epithelial matter, and microorganisms collected upon the teeth.

Neglect in the removal of sordes results in tooth caries, particularly in localities habitually so unclean.

The removal of salivary calculus is accomplished by two principal plans, the push-cut method and the pull-cut method, each with its advantages.

By the push-cut method the blade of the scaler, which has a blunt chisel edge, is forced between the calculus and the enamel, traveling in the direction of the root. In its use the principal danger is the slipping of the instrument to the gum tissue beyond, and this accident should be well guarded against by first securing a positive and sufficient hand rest.

By the pull-cut method, the blade of the scaler, which has a hoe point of about 28 degrees, is first passed under the free margin of the gum, its point engaged on the ledge of the calculus and its removal accomplished by a pulling force applied toward the crown of the tooth or in a plane parallel with the long axis of the tooth. Care should be taken, in passing the instrument under the free margin, not to lacerate the gums. Pen grasp should be used and a secure hand rest obtained before making an effort to remove the deposit.

Which teeth are to be scaled first is not important, yet if attention is first directed to the lingual surfaces of the lower incisors, we are able to create an impression upon our patients of the importance of the work in hand. It is here we generally find the heaviest deposits, and by removing these first and allowing them to fall in the mouth, the patient is fully awakened to the need of the service being rendered. The same impressions never seem possible if the removal of the larger masses is left until the last.

The proximal surfaces are best scaled with the pruning hook, draw-cut scaler, or the straight push-cut having a very thin blade and about a 23 degree bevel.

These proximal surfaces will need such attention more from the deposit of serumal calculus than from the salivary variety which is only present in the proximal surfaces after gum recession.

The removal of serumal calculus is much more difficult than that of salivary, as all of the work is done under the cover of the gum, which requires delicacy of touch and the highest degree of digital skill.

Calculus must be distinguished from cementum, bone, and soft tissues simply by the sensation of touch conveyed through the contact of the instrument with the structures in question.

The surface of roots, where the attachment of the pericementum has been lost, must be carefully examined and the removal of all calculus accomplished, and the root or roots must be thoroughly polished as the gum will not regain health where particles of the deposit remain. Several sittings are often necessary to accomplish satisfactory results.

The removal of green stain is principally accomplished by the application of some abradant, such as pumice stone, with a revolving brush in the dental engine. This also polishes the crowns of the teeth, removing the small particles of calculus still adhering to them after scaling.

Hydrogen dioxide (H_2O_2) added to the powdered pumice in place of water will assist in removing the stains and particularly green stain, of which it is a partial solvent. Following the use of pumice the gums should be thoroughly syringed with water to remove any trace of the pumice which is insoluble in the mouth and should not be left around the free margins of the gums.

A clean new rubber cup should be used and a fresh mix of the paste made for each patient as a means of preventing the transmission of disease, as well as from a standpoint of cleanliness. As well might all our patients be asked to use the same toothbrush, a thing not thought of even by members of the same family.

The removal of sordes is a matter which must be left to the efforts of the patient. Its accumulation about favorable portions of the teeth and mouth is but the matter of a night or a day, and upon its speedy and frequent removal depends the salvage of the teeth from the ravages of caries.

The toothbrush is the one great cleansing agent and nine-tenths of the removal of sordes is accomplished purely by mechanical abrasion through the movements of the bristles of the brush over the surface of the teeth. The movements of the bristles should be not only crosswise to the long axis of the teeth, but also from root to crown and vice versa, that the travel of the bristles may parallel the gingivae, enter the embrasures, and traverse the grooves and fissures.

Hydrogen dioxide is the only agent which can be used in the mouth in sufficient strength to dissolve sordes and not injure either the hard or soft oral tissues. This may be used either upon the brush or as a mouthwash. The dissolution of sordes is accomplished by oxidation.

The massage of the gums is advised to remove all unsolidified calculus, food particles, and other foreign substances from beneath the free margins of the gums, as this appears to be the only satisfactory method of cleansing these spaces. The massage is also most beneficial to the gums. It stimulates the circulation, retards tissue waste, and lessens the deposit of serumal calculus, and in addition forces away what has been precipitated before it has an opportunity to solidify.

Instructions to patients as to the care of their teeth is an all-important duty of the dentist, not only from the standpoint of what is best for the patient, but because much of the dentist's reputation as an operator depends upon the care given the teeth by the owner subsequent to the making of fillings, for upon their environment depends their permanency. Comparatively few individuals know how to care for the mouth properly, and many will insist to their dentist that they are most careful of their oral habits, when, upon examination, the dentist finds surfaces which appear never to have been cared for in the least. They have failed to reach these surfaces with their brush.

The technic of proper brushing should be thoroughly explained, with special reference to reaching the surface which the patient seems to be neglecting. Instruct him as to the massage of the gums with the finger tips, rubbing not only crosswise but also from root to crown, assuring him that if the gums bleed easily it is all the more essential that he repeat the operation, and that finally the gums will regain their normal health and then will not bleed under the treatment advised.

The use of floss silk, for passing through the proximal spaces to clean contacting surfaces by wiping off the embrasures and reaching points inaccessible to the brush, should be demonstrated to the patient.

Care should be taken not to snap the thread past contact points as it may lacerate the gums.

Toothpicks have no place in the care of the teeth and should be prohibited by law, especially those of soft wood so commonly found on the market and at public eating houses. Their square corners and slivered ends irritate the gums, causing their disease and recession, thereby destroying the natural protection to the most vulnerable portions of the teeth.

Summary

Since prophylactic care of the teeth by the patient assisted by the dentist has won the major battle to date, it behooves the dentist to extend to every patient full and careful instructions as to oral hygiene. This includes the diet, particularly of the younger patients, the mechanical cleaning of the teeth, and the stimulating massage of the supporting structures.

CHAPTER V

INSTRUMENT NOMENCLATURE

A dental instrument is an appliance or tool by means of which a dentist performs dental operations. It is quite essential that we learn the names and uses of the instruments most in use if we are to understand the teaching of operative procedures.

Instruments are named according to the purpose for which they are intended, where and how they are used, by describing their working points and the shape of their shanks.

An order name describes that for which an instrument is used, as, for example, excavator, clamp, mallet, plugger, burnisher, etc.

A suborder name describes where or how an instrument of a given order is used, and is made by inserting a prefix before the order name. Examples are: hand pluggers, push or pull scalers, etc.

A class name describes the working point of an instrument. Examples are: serrated plugger, ball burnisher, chisel, hatchet, etc.

A subclass name describes the shape of the shank, and is made by prefixing this description to the class or order name or to both combined. Examples are: bayonet plugger, binangle chisel, monangle hatchet excavator, etc.

Rights and lefts are made as further divisions of many of the subclasses of instruments, and this division is especially advantageous in the spoons, binangle contra-angle hatchets, and marginal trimmers, as it enables the user to do the work by a movement of the instrument from right to left or left to right, respectively.

An excavator is that order of hand instrument used in the removal of tooth substance preparatory to the making of a filling.

A chisel is that class of excavator which has the cutting edge placed at right angles to the shaft, is sharpened by grinding on one side only, and is used by a pushing force applied in the direction of the long axis of the shaft.

The chisel edge is made with a bevel at an angle calculated to plane and cleave a substance possessed of a grain, and so tempered as to retain an edge when working on hard substances.

The use of the chisel is, therefore, the cleaving and planing of enamel. The planing of dentine may be done with a chisel or with other instruments of a similar edge.

Chisels are divided into subclasses according to the shapes of their shanks, as, straight, binangle, contra-angle, etc.

A hoe is that class of excavator with the cutting edge at a right angle, with the shaft sharpened on the distal side only, and is used by a pulling force applied parallel to the long axis of the shaft.

Hoes are divided into sub classes according to the shape of their shanks, as, monangle, binangle, contra-angle, and triple-angle contra-angle. The hoe is used mostly for cutting dentine.

A hatchet is that class of excavator with the line of the cutting edge laid in the plane parallel to the long axis of the shaft.

Hatchets are divided into subclasses like the hoes, according to the shape of their shank, as, monangle, binangle, and triple-angle contra-angle. The hatchet form is indispensable for the construction of flat walls and internal surfaces, the straightening of lines, and the sharpening of angles.

A gingival marginal trimmer is a modified hatchet.

A spoon is that class of excavator which resembles in most respects the hatchet, except as to cutting edge. This is sharpened only on one side, which is rounded like the convex side of the bowl of a spoon, from which it derives its name. The cutting edge is rounded and sharpened to a thin edge. They are always made rights and lefts.

The use of a spoon is to remove foreign matter and softened dentine from the tooth cavity.

The angles between the shank and the working part are designated as monangles, binangles, and triple-angles, according to the number of angles used, being one, two, or three, respectively.

The contra-angle is the placing of such angles in the shank of the instrument so as to bring the cutting edge near the central line of the shaft, which removes the tendency to tip or turn in the hand during use.

Binangles and triple-angles are properly made only when contra-angled, provided the cutting edge is more than 3 mm. from the central line of the shaft.

Formula Names.—Some instruments have the formula stamped on the handle in figures. There are generally three numbers given. The first is the width of the blade in tenths of a millimeter. The second is the length of the blade in millimeters. The third is the angle of the blade with its handle, given in the hundredths of a circle.

When a four-number formula is given, as with gingival marginal trimmers, the second number in the name designates the angle of the cutting edge of the blade with shaft or handle. This is also given in the hundredths of a circle.

A plugger is an order of instrument for the packing of material in the making of a filling. Those for gold are serrated on the working point in such shape as to result in a surface made up of prisms. These prisms should be of exactly the same size on all the points used in any individual filling when packing cohesive gold, as the interchange of points of different-sized serrations causes bridging. (See manipulation of cohesive gold.)

The dental engine is almost indispensable and when properly used is a blessing to the patient and a timesaver to the dentist. It is all too frequently used, however, especially by students and young practitioners, to do things which can be done properly only with the hand instruments. The misuse of the dental engine has caused the public to regard it as the climax of all pain-producing instruments in the dental office, when, in reality, if the work which should be done with the engine is properly done, only a few seconds of pain is induced in the preparation of a very severe cavity.

The engine bur is the working point of the engine and is made in many shapes and sizes. Those, however, which are round and inverted cones, whose diameter is smaller than 1 mm., are most frequently indicated. The tendency of the beginner is to use too large burs. Burs are primarily intended to cut dentine in outlining cavity walls, and to undermine enamel to facilitate the use of hand instruments, and they should rarely come in contact with the enamel.

The most indispensable use of the engine is for the polishing and grinding necessary to the successful termination of many varied operations, both in and out of the mouth.

The sharpening of instruments is of the utmost importance and is by no means accomplished without skill. No more can a dentist execute finished work with dull instruments, than can a tradesman, whose tools must be keen of edge if he is to produce work which is worthy of his craft. Again, dull instruments cause an undue amount of pain at each attempt to cut, whereas, when sharp, the pain is less and the effort in cutting is materially lessened resulting in a saving of time and energy on the part of the dentist. A hard, smooth Arkansas stone is the only suitable abradant and should be well oiled and wiped with a cloth after each use.

The instruments as sold to the dentist are usually made and sharpened especially for the use intended, and, in sharpening, care should be exercised that the degree of angle in the bevel edges is not changed.

An instrument is best tested for sharpness by placing the edge with light pressure against the fingernail and attempting to move it across the surface at right angles to the edge. If it catches or clings to the nail, it is ready for use.

It is the working point of an instrument which interests a mechanic in the tool he buys: its quality, its size and shape.

After purchase, it is the job of the owner to keep that instrument in fine working condition. Few instruments at time of purchase are ready for service.

CHAPTER VI

CAVITY NOMENCLATURE

A cavity nomenclature is necessary so that we may understand one another in conversing about the formation of cavities, the description of their several parts, and the methods of procedure in the preparation of cavities for fillings.

Cavities derive their names from the surfaces of the teeth in which they occur. Thus, occlusal cavity, buccal cavity, labial cavity, etc., are cavities occurring in the surfaces named.

A simple cavity is one which involves but one surface.

A complex cavity is one which, either from decay or extension in preparation, involves more than one surface.

Complex cavities are named by combining the names of the surfaces of the tooth involved, as mesio-occlusal, disto-occlusal, mesio-disto-occlusal, etc.

An axial surface cavity is one which occurs in an axial surface.

Proximal cavities are axial surface cavities occurring in the proximal surfaces and are divided into two classes, namely, mesial and distal.

Cavities are divided as to their origin into two groups:

First, pit and fissure cavities, which are those originating in the minute faults in the enamel. (See Figs. 5 and 6.)

Second, smooth surface cavities, which are those occurring on surfaces without defects in the enamel but habitually unclean. (See Figs. 7 and 8.)

Cavities are divided according to similarity in line of treatment, into six classes:

Class One. Those cavities beginning in structural defects. (Pits and fissures.)

Class Two. Those cavities in the proximal surfaces of bicuspids and molars.

Class Three. Those cavities in the proximal surfaces of incisors and cuspids not involving the incisal angle.

Class Four. Those cavities in the proximal surfaces of incisors and cuspids which require the restoration of the incisal angle.

Class Five. Those cavities in the gingival third of the labial, buccal, and lingual surfaces not originating in faults in enamel.

Class Six. Abraded surfaces.

The outside walls of a cavity are those walls placed toward the outside surfaces of a tooth. They take the names of the surfaces of the tooth toward which they are placed, as, in an occlusal cavity the outside walls are buccal, distal, mesial, and lingual, while the fifth or internal wall is the pulpal.

The pulpal wall is that inside wall of a cavity which covers the pulp and is in a plane at right angles to the long axis of the tooth.

In case the pulp is removed, the pulpal wall becomes the subpulpal wall, in multirooted teeth.

The axial wall is the inside wall of an axial surface cavity which covers the pulp and is in a plane parallel to the long axis of the tooth.

In case the pulp is removed in an axial surface cavity, the axial wall becomes an outside wall and takes the name of the surface of the tooth toward which it is placed.

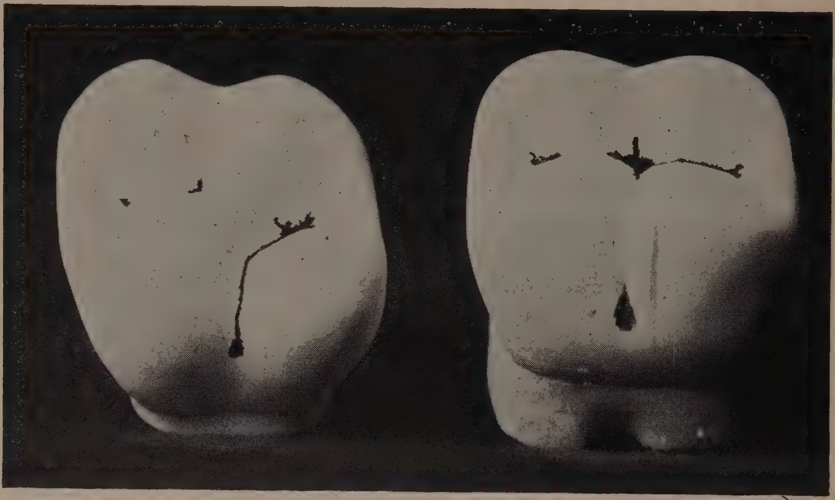

Fig. 5.—Defects in enamel.

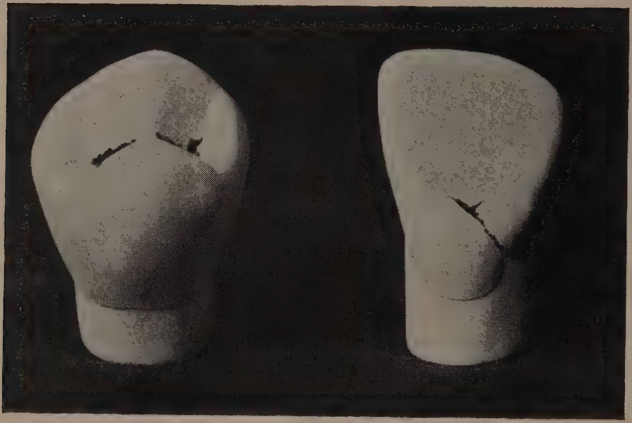

Fig. 6.—Defects in enamel.

The gingival wall is the inside wall of an axial surface cavity placed toward, and running in the same plane as, the gingivae.

Both gingival and subpulpal walls may be present in cases of pulp removal in mesio-occlusal, disto-occlusal, and mesio-disto-occlusal cavities when each is on a different level and the individuality of each wall is retained.

The inside walls of a cavity are those placed toward the pulp or root of a tooth.

The base of a cavity, or seat of a filling, is that portion of a cavity situated at right angles to the lines of force to which it is most likely to be subjected. Generally speaking, this is the gingival or pulpal wall, or both, where these walls are present, as in a step cavity.

A line angle is formed where two walls of a cavity meet along a line and is named by joining the names of the walls so meeting.

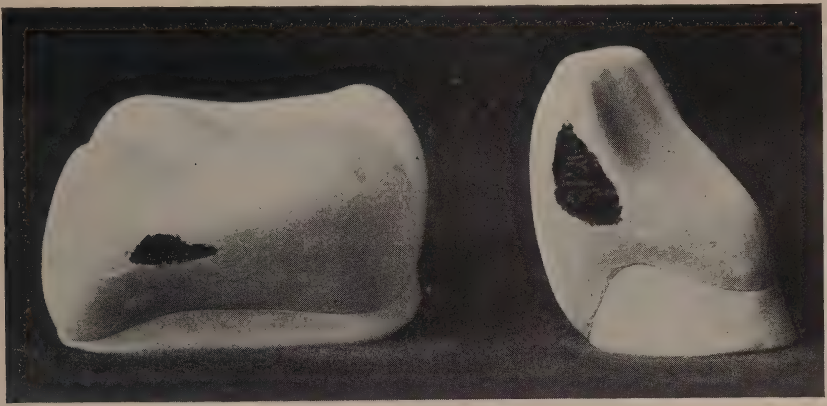

Fig. 7.—Smooth surface decay.

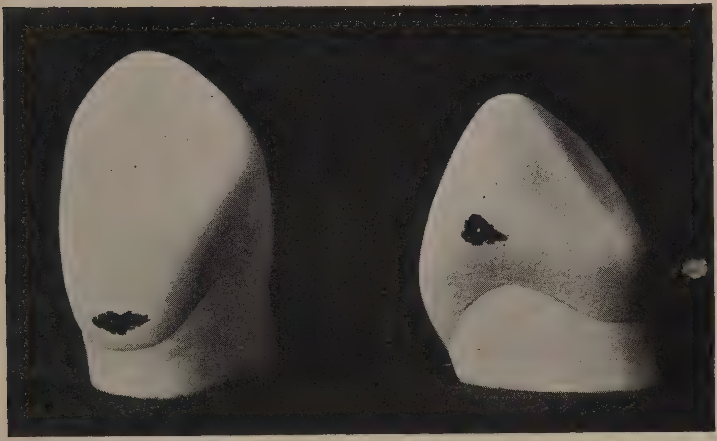

Fig. 8.—Smooth surface decay.

There is but one exception to this rule. That is where the labial and lingual walls of a proximal cavity in the incisors and cuspids meet along a line. By applying the rule this would be called the labiolingual angle, but for convenience this is named the "incisal-line angle."

A point angle is formed where three walls of a cavity meet at a point and is named by joining the names of the walls so meeting.

There is but one exception to this rule. The point of junction of the axial, labial, and lingual walls in proximal cavities in the six anterior teeth is named, for convenience, the "incisal angle."

A simple cavity has two sets of line angles: First, the internal line angles surrounding the internal wall, which is the axial wall in axial surface cavities, and the pulpal wall in occlusal cavities. The second set of external line angles is formed by the junction of the outside walls with each other.

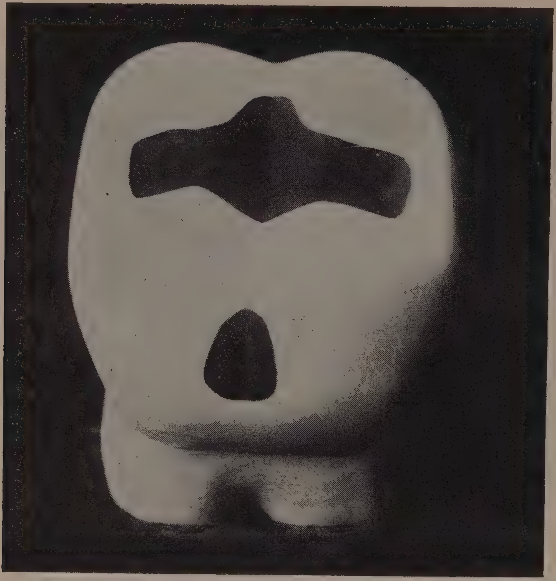

Fig. 9.—Class One cavities filled.

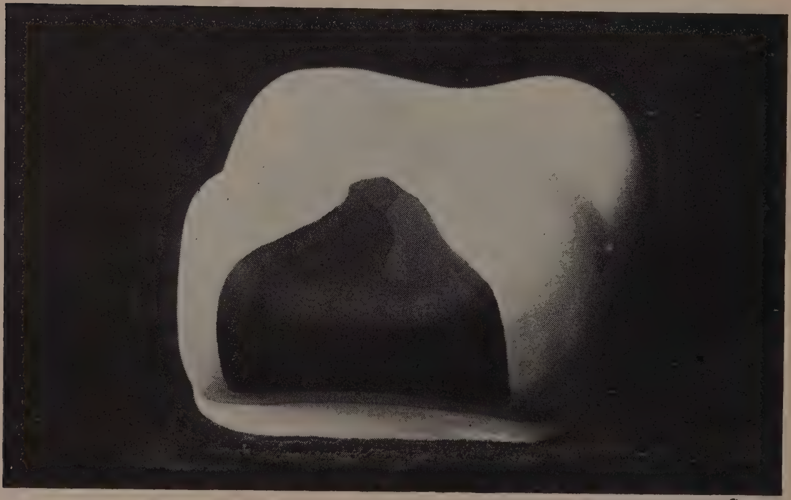

Fig. 10.—Class Two cavity filled.

The enamel margin is that point on the surface of the tooth where the cavity begins in enamel.

The external enamel line is the entire outline of the cavity at its enamel margin.

The cavosurface angle is the angle formed by the junction of the wall of the cavity with the external surface of the tooth.

The base of the cavosurface angle is the external enamel surface.

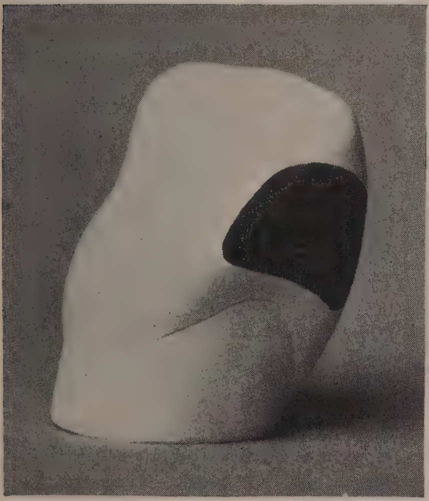

Fig. 11.—Class Three cavity filled.

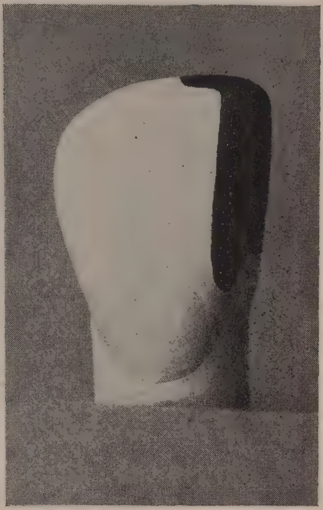

Fig. 12.—Class Four cavity filled.

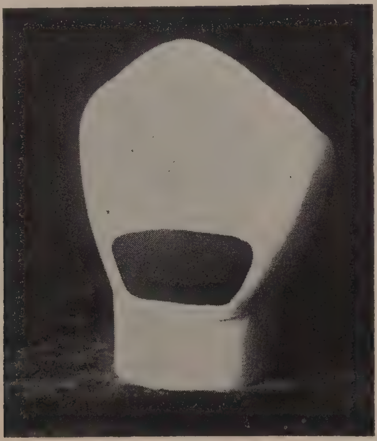

Fig. 13.—Class Five cavity filled.

The marginal bevel of a cavity is the deflection of a cavity wall from its established plane, near the external enamel line.

It is necessary that beveling be restorted to in order to manage the enamel margins, direct the external enamel line, and control the degree of the cavosurface angle, without disturbing the general retentive form of the cavity.

The bevel angle is the angle formed by the junction of the marginal bevel with the remaining portion of the wall of which it is a part.

The base of the bevel angle is the remaining portion of the cavity wall.

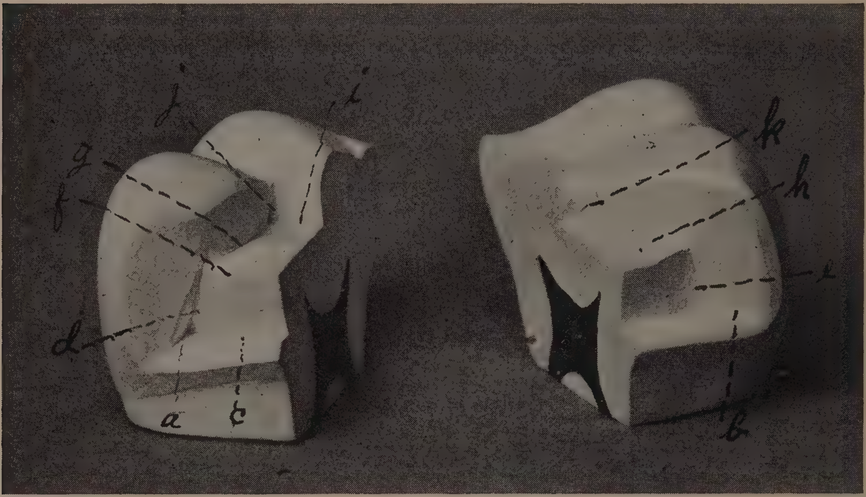

Fig. 14.—Bisected molar in which a mesial Class Two cavity has been cut and line angles indicated. The line angles are: *a*, gingivobuccal; *b*, gingivolingual; *c*, gingivoaxial; *d*, axiobuccal; *e*, axiolingual; *f*, axiopulpal; *g*, pulpobuccal; *h*, pulpolingual; *i*, pulpodistal; *j*, distobuccal; *k*, distolingual.

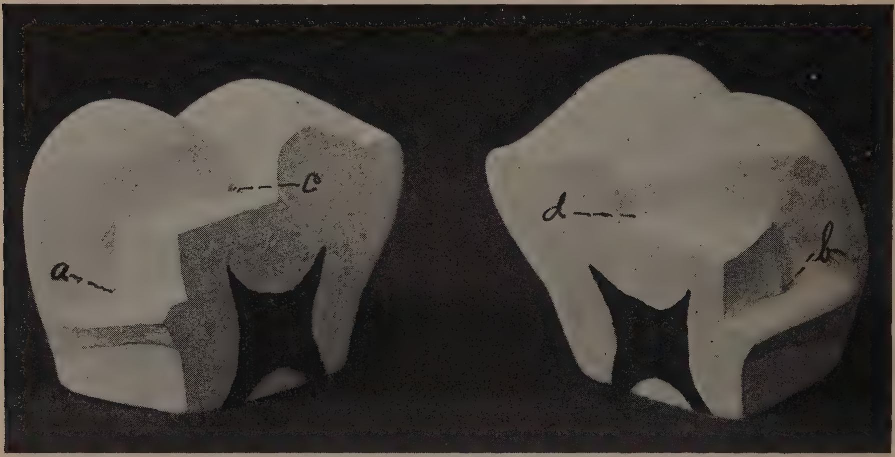

Fig. 15.—Bisected molar in which a mesial Class Two cavity has been cut and point angles indicated. The point angles are: *a*, gingivoaxiobuccal; *b*, gingivoaxiolingual; *c*, pulpodistolingual; *d*, pulpodistobuccal.

The bevel angle is covered when the filling is in position. Its distance from the enamel margin depends upon the filling material used, and the location in the cavity outline. To illustrate: With porcelain inlays and amalgam the bevel angle must be deeply buried, resulting in a thicker edge of filling material. With cast gold inlays and platinum combination fillings the bevel angle should be near the surface, resulting in a short marginal bevel. The distance of the bevel angle from the cavosurface angle must not affect the degree of the latter angle but determines only the length of the bevel and the thickness of the filling at its margin.

The planes of a tooth are three in number: horizontal plane, mesiodistal plane, and buccolingual plane.

The horizontal plane is at right angles to the long axis of the tooth.

The mesiodistal plane passes through the tooth from mesial to distal, parallel with the long axis.

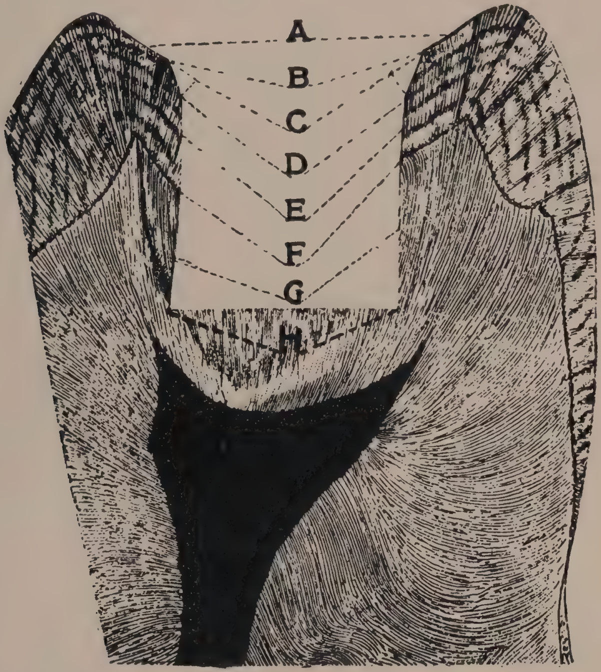

Fig. 16.—*A*, External enamel surface; *B*, cavosurface angle; *C*, marginal bevel; *D*, bevel angle; *E*, enamel wall; *F*, dentoenamel junction; *G*, dentinal wall; *H*, base line angles.

The buccolingual plane passes through the tooth from buccal to lingual, parallel with the long axis of the tooth. In the six anterior teeth this plane would be labiolingual.

Summary

A common cavity nomenclature is essential to avoid many misunderstandings in listening to lectures and in writing and reading papers.

Familiarize yourself with the nomenclature of the late Dr. G. V. Black, as used in this and other books of the author. It is simple, complete, and easy to remember.

CHAPTER VII

TREATMENT OF HYPERSENSITIVE DENTINE

Hypersensitive dentine is dentine which is more than normally responsive to mechanical or chemical irritation and thermal changes.

Normal healthy dentine is only slightly sensitive, but when exposed to abnormal conditions and irritating agents it may become excruciatingly hypersensitive.

The sensations are conveyed to the pulp by means of the contents of the dental tubules which are prolongations of the odontoblasts. The odontoblasts are thickly surrounded by the terminal fibers of the nerves within the pulp.

The content of the tubules is largely protoplasm and although this has the power of transmitting sensation in response to irritation, it has not yet been demonstrated that the nerve fibers enter the tubules or penetrate their contents. Hence it cannot be said that there is nerve tissue within the dentine.

The direct cause of sensitive dentine is the loss of the enamel which is the natural covering of the dentine.

The most common agent in the removal of this normal covering is caries, which exposes the dentine to mechanical injury through contact with foreign substances and chemical irritants, particularly the acids of fermentation.

Rapidity of caries has much to to do with the degree of hypersensitiveness in dentine. In the white and light stages or rapid forms of caries the sensitiveness is most exalted, while with the dark, yellow and brown varieties, it is not so marked, and with the black or slow progressing form of caries the sensitiveness is scarcely above normal.

The most sensitive part of a carious tooth is at the junction of the dentine with the enamel or cementum at the periphery of the tubules. It is therefore evident that the second stage of caries will show a higher degree of hypersensitive dentine than the deep-seated stages, and that the preliminary steps in cavity preparation in this division of caries will be more painful than the deeper cuts into the dentine, as then the more sensitive part has been passed.

Mechanical abrasion is also an agent which produces hypersensitive dentine by first wearing away the enamel and then encroaching on the dentine. This process, however, may be so slow and the irritation so slight as to act as a stimulus to the odontoblasts and result in the obliteration of the dental tubules by the deposit of calcic matter termed "tubular calcification." When this is the result, all sensation may be absent.

Exposure of cementum through gum recession is another exciting cause of hypersensitive dentine, aggravated by allowing the accumulation of sordes about the exposed cementum.

Abnormal oral secretions often produce hypersensitive dentine and may be particularly looked for in the convalescent stages of fevers, as well as in dyspepsia, neuralgia, pregnancy, pulmonary tuberculosis, and acute rheumatism.

Hypersensitive dentine is found in poorly calcified dentitions including the teeth of the growing child, teeth that have not been erupted for more than a few months, and the teeth of those who follow indoor lives, particularly if they are under a heavy mental strain or anything which may produce nervous irritation or debility.

The varying temperaments of patients must be studied and understood to cope best with the problem of hypersensitive dentine. The suffering is actual upon the part of some, while there are those who magnify every pain and seem to be able to stand nothing; they make as much fuss about a pin stick as it would be possible for them to make were they thrust through with a bayonet. The operator must separate these classes and vary his methods of treatment. He must understand the actual conditions and, by kind words of encouragement and a positive procedure, stimulate the nervous to withstand the necessary pain. This can be done only when the operator has full control of his own feelings, seeing to it that his temper is not ruffled, for, having lost control of himself, he has no control over the patient.

A highly wrought, nervous temperament is, by nature, sensitive to impressions, especially augmented by environment or occupation, and calls for the most skillful management of both patient and teeth. People of this type are generally of a high order of intelligence and, when handled by a master hand, prove a most desirable clientage.

Patients of this temperament will stand being hurt for a short time provided something definite has been accomplished. They should be advised at times as to the coming pain and for what purpose it must be inflicted, such as the forming of an angle or the flattening of a wall, and they should be told, when done, that the end in view has been accomplished. They will stand for no awkwardness or fumbling but admire exactness and precision. This class of patients will reward the dentist most liberally for painstaking efforts and actual achievements. They make the day long, but they serve to stimulate the dentist to his best efforts, and work to the advancement of the really progressive operator.

The irresponsible individuals who have no mental or physical stamina require a strong hand to control them in any emergency in life. They go to the dentist only when forced there by pain, or, if children, are brought by their parents. While a dentist should never be harsh with any patient, yet this class will often necessitate stern commands and a "why, of course" method. In cases of this character where the operator has chosen to assume the role of a disciplinarian, the firm proceeding should universally be tempered with the kindest of tones before the patient leaves the chair, so that he may depart with the impression that the dentist is kind of heart and has been severe only for the patient's good.

The naturally cowardly patient who is strong, healthy, and robust, yet lives in mortal dread of any physical discomfort, is the hardest kind to manage. These patients have generally been raised in luxury and taught by example made by their environment, that they should not even be inconvenienced. They seldom work, and they mistake that tired feeling for sickness. To be hungry, cold, or warm is described by them as "simply terrible." With such, often the best an operator can do is simply to temporize to keep the teeth comfortable. To attempt thorough work merely drives them away to seek gas for painless extraction.

The patient who simulates pain should be detected early and dealt with severely. An operator should remember that a large amount of the gesticulation, grabbing the working hand, cringing, and outcry, is simply voluntary on the part of many patients to inform the dentist that he is hurting them. Most of this can be done away with by the following procedure:

First tell the patient, "This will not hurt you," and proceed to make the statement true by working on enamel margins, even to gently scratching on the external surface. Then tell him, "This may hurt a little," and go on to test the dentine for its sensitive portions. The operator may then proceed to do the less painful parts of cavity preparation. Lastly, when it comes to cutting the angles and sensitive portions, the patient should be warned that this particular place may be sensitive but that a certain amount of cutting is necessary. Advise the patient to hold still for just a second or two, after which he will be allowed to rest. Caution him against moving during this brief period as it will undo what has been accomplished, necessitating his undergoing the pain again. Praise the patient for his bravery when he has complied with the request and advise him as to the work accomplished. All this instills confidence into the patient as to the dentist's skill and as to his knowledge of the place and time that pain may be expected. Nothing unnerves a patient so much as to get the idea that the dentist is not aware of the pain he is inflicting or has little care for the patient's sufferings and when they will end.

The expert simulator of pain will try to make the operator believe he is feeling pain when he is not suffering at all, with the idea that the dentist will be frightened into extreme care in his case. This class is easily detected when the operator scrapes an instrument on a surface where pain is impossible, such as the external surface of a tooth. If the demonstrations of pain continue, it is the operator's duty to inform the patient of his detection of the attempted deception, which will not be further considered, at the same time advising him to save his demonstrations until hurt, when every effort will be made to lessen the pain.

The agents for relief of sensitive dentine are:

First, those which produce a physical change in the contents of the tubules, as desiccation, heat, and cold.

Second, those agents which destroy or disorganize the contents of the tubules, as caustics and escharotics.

Third, those agents which, when applied to the dentine locally, produce a condition of analgesia or absence of sensibility to pain: local anesthetics such as phenol, menthol, morphine acetate, oil of cloves, and novocain.

Fourth, those agents administered with the view of reaching the nerves of the pulp through the general system, such as bromide of potassium, nitrous-oxide, chloroform, etc.

Fifth, the mechanical condition under which the cutting of sensitive dentine is done.

Physical Agents

Desiccation is a physical agent of great virtue in alleviating hypersensitive dentine. It accomplishes the result by extracting the moisture from the tubules, which is a large constituent of the protoplasm.

This is best accomplished by first flooding the cavity with absolute alcohol, which has an affinity for water, and then directing into the cavity a continuous stream of warm air which is more effective if the temperature can be controlled so as to raise it gradually to the highest point tolerable to the patient. Painless cavity excavation can be accomplished to the depth of desiccation, which will vary with different cases.

A continuous stream of cold air will have a similar action through its desiccating effect and is practiced where compressed air is at hand. The force with which the air comes in contact with the cavity walls is a factor in its efficiency.

Heat and cold when moist will produce physical changes in the protoplasm of the tubules sufficient to destroy the sensation of pain.

In any locality of the body a moderate rise in the temperature, particularly moist heat, quickens vital action and heightens functional activity. This is true of sensitive dentine, and the temperature must be materially raised before a stage of paralysis is reached.

The best means of applying this method is to direct into the protected cavity a forceful fine stream of water which can be gradually raised in temperature to the point of toleration, cutting the sensitive part of the cavity while the stream of water is still playing on the point being operated upon.

With the application of cold to any part, vital phenomena of every nature are retarded and entirely cease with the lower temperatures.

The best method of applying this principle is to spray the cavity with a highly volatile liquid, such as ethyl chloride, or sulfuric ether and its combinations with chloroform. The rapid evaporation lowers the temperature, extracting the heat from that with which it comes in contact.

The primary pain in applying these agents may be lessened by filling the cavity, temporarily, with stopping, directing the spray first on this and the surrounding parts, and later removing the stopping, directing the spray into the cavity without causing much pain, provided there is not a hyperemic pulp within the tooth, in which case all thermal changes must be avoided.

The electric current (cataphoresis) as a physical agent to obtund sensitive dentine should be mentioned. It has been used to assist in carrying various drugs into the dentine to facilitate their activity, but its use has proved so unsatisfactory in many ways that further description of this method is unwarranted.

Destroying Agents

Caution in the use of caustics and escharotics to relieve sensitive dentine in deep-seated cavities will save many pulp complications, and great care must be exercised in their use not only for the safety of the pulp but also for the protection of the soft tissues about the tooth. Many caustics are not limited in their action and, when once applied on the dentine, continue their destruction to the envelopment of the pulp. Arsenic trioxide is a notable example of this.

Zinc chloride is one of the oldest and most efficient remedies for hypersensitive dentine. Its action is due to its affinity for water and its coagulating properties upon albumin.

The danger in its use in deep-seated cavities is through the liberation of hydrochloric acid, which causes pain in case of a nearly exposed pulp. This effect may be modified by using it in a solution of one part chloroform and four parts alcohol. Add the zinc crystals in the proportion of 5 grains to the ounce. Clarify by adding a drop of hydrochloric acid.

The methods of using zinc chloride are:

First, saturate a pellet of cotton with the above solution, place in the cavity, and evaporate with a draft of warm air from the warm air syringe or chip blower.

Second, mix a thin paste of zinc oxychloride cement. Paint the sensitive dentine with this cement and cover with stopping or gutta-percha. Many times, after a few days or weeks, excavation may be accomplished with little pain.

Caustic potassa and phenol, equal parts (Robinson's remedy), often relieves sensitiveness of the dentine and is applied by placing a pledget of cotton in the cavity, always with the rubber dam in position to protect soft tissues.

Silver nitrate may be employed to good effect upon exposed surfaces of dentine in the posterior parts of the mouth, such as those on the occlusal surface of molars due to abrasions, or exposed cementum. It reduces sensitiveness, and by forming the albuminate of silver it retards decay even so far, in some cases, as to render the surfaces to which it has been applied immune to caries. On account of its discoloring effect its use is not permissible in parts exposed to view.

Local Anesthetics and Anodynes

Novocain stands first as a local anesthetic to desensitize dentine. It paralyzes the terminal fibers of the sensory nerves, and, when it reaches the odontoblastic layer of the pulp, its action is most prompt and profound. This latter effect, however, is never sought unless pulp extirpation is intended. This will be fully considered in the chapter on pulpectomy,

The methods of using novocain for sensitive dentine are slow absorption and injection by pressure.

The slow absorption method is best practiced by putting into the cavity a tablet of pure novocain; over this, place a pledget of cotton which has been moistened with the normal salt solution, and proceed to fill the tooth with stopping, seeing the cavity again for excavation in twenty-four or forty-eight hours.

Pressure anesthesia of the dentine may be accomplished in two general ways. The dentine should be thoroughly sterilized, the above application of novocain in the normal salt solution made, a piece of unvulcanized rubber placed over this, and all crowded into the cavity with as much force as the patient will permit.

High pressure syringes are sometimes of service to desensitize the dentine, but their use for this alone has never become general practice due to the danger of pulp infection and affection.

Phenol (known to the laity as carbolic acid) is a valuable remedy for hypersensitive dentine, as well as for materially lessening the pain caused by the blast of air from the chip blower, and should never be forgotten when the patient complains of the air causing pain. In addition to coagulating the albumin in the tubules, it possesses analgesic properties.

The method of using phenol for sensitive dentine is to carefully desiccate the dentine with alcohol and warm air, applying a pledget of cotton saturated with the phenol and directing thereon a current of warm air until the cotton is nearly or quite dry. This should be repeated as often as the case demands.

Oil of cloves is a valuable remedy in this respect and the method for its use is the same as that just described for phenol.

Oil of cloves and phenol combined (two parts phenol and one part oil of cloves), applied to the dry open cavity and evaporated therefrom with the current of warm air, is more effective than either phenol or oil of cloves alone. This method is recommended by the fact that it is a good means of sterilization, it is a pulp pacifier in deep cavities, and no injury can reach the pulp provided the temperature of the current of air is not too hot.

Agents Administered Through the General System

Potassium bromide in drop doses three times a day for forty-eight hours previous to a visit to the dentist will do much to remove the nervousness caused by the fear of the intended visit and serve to minimize the pain to be endured.

Nitrous oxide is of service in extreme cases where the operation is short, such as the sharpening of angles or the making of a convenience angle for starting a filling. The operator, however, must have the full cooperation of the patient with the absence of all fright.

Chloroform slowly administered and only to the first stage of anesthesia is a most valuable means of dealing with severe cases. This is particularly true of the A. C. E. mixture (alcohol, chloroform, and ether, equal parts). The primary effect is to paralyze the sensory nerves, as in the ends of the fingers, the skin, and mucous membrane in general, and also in the tooth's pulp with the fibers ending in the odontoblastic layer of cells wherein abundant sensitiveness has been developed.

The method of administration is quite the same as that for any other operation except that it is not carried past the first stage of anesthesia. That part of the preparation of the cavity not producing pain is carried out, after which the dental chair is tipped back to as recumbent a position as will admit of operating. A napkin is then spread over the lower part of the face, leaving the eyes uncovered. The chloroform, or better, the A. C. E. mixture, is added, first a drop or two at a time slowly, then carried to the point where the patient feels a tingling sensation in the finger tips or shows that he begins to feel the effects of the drug. The anesthetic should never be crowded or confined while the patient can smell the chloroform, but can be pushed more rapidly when the olfactory nerves have been paralyzed so that the sense of smell is lost. It is not long thereafter until the dentine can be excavated painlessly. As soon as the operator begins to operate, the assistant should hold to the nostrils a large-mouthed bottle of the anesthetic to prolong the stage of anesthesia reached. At no time should the patient be sufficiently under the influence of the anesthetic to be unable to converse coherently or to answer intelligently the questions put to him.

It must be remembered that any anesthetic has its dangers, particularly when its use is abused, but the above method can be recommended as comparatively safe. One writer reports its use in over 20,000 cases without ill effects. It is true that a large percentage of the cases wherein death has resulted from the administration of chloroform or ether have occurred in the first few breaths, due, we believe, to a strong mixture used before the nerve filaments of the air passages have been anesthetized.

If a few breaths administered by the open method, as above, proved fatal, literature would be replete with long accounts of druggists, physicians, dentists, and others, who met death by smelling of opened bottles of these drugs.

Rapid breathing as a means of producing peripheral anesthesia should receive consideration, not only for hypersensitiveness of the dentine, but for other minor dental operations, such as the use of the hypodermic needle, the lancing of abscesses, and the extraction of teeth. The anesthetic effect is brought about by superoxidation within the tissues caused by charging the blood with an abundance of oxygen.

This method is employed by instructing the patient to take deep, long breaths as rapidly as possible until a sense of dizziness is brought on, when an anesthetized condition lasting from thirty to sixty seconds will be found available for operating.

Mechanical Conditions

The mechanical conditions under which the cutting of dentine is done are a great factor in the amount of pain produced.

Sharp instruments which cut without pressure upon the contents of the tubules cause much less pain than dull ones even with hand instruments. This is also true with rapidly revolving engine burs because the heat produced by the friction caused by rubbing surfaces which are worn away rather than cut is the chief source of pain in the use of burs.

The cutting should be done as much as possible at a right angle to the long axis of the tubules, rather than following their course with pressure toward the pulp or in a line with their long axis.

Novocain used to block the nerve trunks leading to the tooth or teeth, or injected by the infiltration method, is of major importance in dealing with sensitive dentine. This has been given full consideration at the end of Chapter II.

Referring to the continuous stream of cold air mentioned under *Physical Agents,* we are using with considerable satisfaction the equipment designed by Dr. V. H. Carpenter, which carries a tubing attached to the unit, and follows the engine arm and hand piece to a point near the working point and tooth cavity, maintaining a cool bur and lowering the temperature of the cavity wall. This relieves the assistant and keeps the cavity free from dust chips and a reasonable amount of saliva in the absence of the rubber dam, as in preliminary cavity preparation.

CHAPTER VIII

CAVITY PREPARATION (GENERAL CONSIDERATIONS)

Definition of Cavity Preparation.—Cavity preparation is the term applied to those mechanical procedures upon a tooth looking to the making of a filling, as well as those changes and extension necessary to resist stress and prevent a recurrence of decay.

Affected dentine is dentine which has been acted upon by lactic acid in advance of the microorganisms of caries.

Infected dentine is dentine which has been penetrated by microorganisms.

Objects in Filling Teeth.—There are four general objects in view in the filling of teeth:

First, To arrest the loss of tooth substance.
Second, To prevent recurrence of caries.
Third, To restore full tooth contour.
Fourth, To improve the primary conditions as to the performance of function and esthetic effects.

A completed cavity should be a combination of flat walls coming together at definite angles, surrounded by an external line made up of the largest curves permissible.

The line angles within a cavity, which are a necessary part of resistance and retention forms, should never be permitted to end in the external enamel line.

Order of Procedure.—To simplify the preparation of all cavities and to insure the observance of certain fundamental principles, it is well to follow a definite order of procedure. This will greatly facilitate the operations of the student and lead to the establishment of habits by the practitioner which will stand for thorough methods of execution.

The following would seem to be the natural order:

First, Gaining access.
Second, Outline form.
Third, Resistance form.
Fourth, Retention form.
Fifth, Convenience form.
Sixth, Removal of remaining decay.
Seventh, Finishing of enamel walls.
Eighth, Toilet of the cavity.

Modification of form is necessary in cavity preparation to meet the various properties of the different filling materials used. This is particularly true when considering the difference in edge strength and flow of metals and alloys.

The character of the oral fluids, the evident care bestowed upon the teeth, the condition of the patient's health, the age of the patient, and the life expectancy of the patient and of the individual teeth, will frequently require a modification of cavity formation to resist best the recurrence of decay and the dislodgment of the filling through stress.

CHAPTER IX

GAINING ACCESS

Definition.—Gaining access is the term applied to those procedures necessary to make sufficient room for the proper introduction of the filling.

Sufficient access is important that we may have the advantage of space to handle properly the instruments and appliances used in the procedures of making a filling, that we may be able to introduce the filling into the cavity, that there may be complete contour restoration of tooth form, and that the desired contact relation may be established to the adjacent tooth.

Access to the tooth is the first consideration and will involve the opening of the mouth to a sufficient degree to permit the free use of the usual appliances. The proximal spaces used for the adjustment of the dam should be examined to make sure that the rubber and ligatures will pass to the gingival line without injury. A sufficient number of teeth should be isolated, say four or five, to give a clear and unobstructive view of the cavity and surrounding teeth.

The operator must be able to bring the cavity into full view. In cases where there has been considerable decay subgingivally, and tumefaction of the gum septa has taken place, proper access will involve the packing of the cavity with a tampon of cotton which has been dipped in chlora-percha, or a packing of gutta-percha, for a period of twenty-four or forty-eight hours, to crowd the encroaching gum tissue from the cavity. A neglect of this consideration of access will often make proper management of the gingival wall and margin very difficult or impossible.

Surgical access may be practiced on the cavity margins, when all tooth structure thus removed will subsequently be replaced with filling material. It may be practiced on the gum septa when there has been excessive tumefaction in the proximal space.

Formerly, this method was practiced with Class Five cavities where the decay was to a marked extent subgingival and it was desired to make a cohesive gold filling. Much of this questionable practice may now be avoided, however, by the use of the gold inlay, made from the wax model, as the presence of the overlying gum is no considerable hindrance.

Access as Related to Restoration of Proximal Space.—As tooth substance is lost through decay in proximal cavities, there is in most cases a movement of the teeth to the proximal, encroaching on the normal space, robbing the gum of sufficient room for full festoon. It is wholly impossible in such cases for the operator in making a filling to restore tooth contour or leave a normal amount of room for the rehabilitation of the gum septa, without resorting to separation. The surfaces of a tooth which are covered with healthy gum tissue are practically immune from both primary and secondary caries, and it is greatly to the advantage of a filling, the outline of which is in the proximal gingival third, to be so protected. Good access should be gained by preliminary separation, so that when the completed filling with its full tooth-form restoration is in place, there is restored the normal proximal space for the habitation of the gum septa. *A failure to regard this fact* will result in a strangulated, diseased, and dwarfed septum, inviting an accumulation of the enemy of tooth structure and an early loss of the filling through secondary caries.

Restoration of tooth form is essential that the full function of the masticating organs may be established and maintained. It is also desirable for esthetic reasons, as the more nearly a dentist approaches complete tooth contour restoration, with all its details, the more pleasing is the appearance and the more artistic the result.

Proper contact point is often impossible unless sufficient access has been secured through separation. This contact should be a point of contact, the embrasures widening therefrom in every direction. It should be in no sense a line of contact or a surface, no matter how small. It is advisable many times, in this respect, to improve on nature by slightly varying the surface of the filling from the original shape of the tooth, as often the predisposing cause of the primary decay has been defective contact.

The saving of tooth substance is materially affected by access through preliminary separation, particularly in the placing of inlays, as the more thoroughly this first step in procedure has been accomplished the less cutting will be required for convenience form, a point of no small importance.

Methods of Separation.—There are two classifications of separation to gain access: preliminary, which is also slow separation, and immediate, which is rapid, both being a part of gaining access.

The preliminary is a part of the first consideration, while immediate separation is brought to our attention during the introduction of the filling.

Preliminary separation is best accomplished in proximal cavities in bicuspids and molars (Class Two), by packing into the partially excavated cavity an excess of gutta-percha base plate. A few days, or in some instances a few weeks, will suffice to accomplish the desired result, particularly if the patient uses that location in the mouth for daily mastication of solid food.

In the proximal space in the six anteriors, preliminary separation is best accomplished by the use of cotton tampons tightly packed in the cavity and ligatured securely to position.

Immediate separation is best accomplished with the mechanical separator, which should be used to gain additional access not already secured by preliminary separation, or may be used primarily when only a small amount of additional space is desired. This instrument should be adjusted as soon as convenient after securing outline form, and removed only when the filling is finished.

Avoid gum injuries in the use of elastic rubber. In the use of the methods given, care should be used not to crowd the gum tissue as permanent injury may result.

There are other materials used in slow separation, such as linen tape, wooden wedges, etc., each with its merit and indicated use.

Soreness resulting from tooth separation should be treated as any case of acute pericementitis, by giving the tooth physiologic rest and using stimulating applications on the gum over the tooth's root.

CHAPTER X

OUTLINE FORM

Definition.—Outline form is that part of cavity preparation which determines the area of the tooth surface to be included within the external enamel line.

Rule 1. Extend to Sound Enamel.—All cavity margins should be extended until all indications of surface decay have been included.

Rule 2. Obtain Full-Length Rods.—If necessary, further extend the outline until full-length enamel rods, supported by sound dentine, have been reached.

Rule 3. Self-Cleansing Margins.—Extend the cavity outline until the surface of the filling can be so formed that the enamel margin not protected by the gum will be mechanically cleansed by the excursions of food in mastication.

Rule 4. In Relation to Developmental Grooves.—A cavity outline should not follow a developmental groove or parallel it so closely as to leave a small strip of intervening enamel. The outline should cross the grooves as squarely as possible.

Rule 5. Fissures and Sulcate Grooves.—All fissures, sulcate grooves, and angular developmental grooves encountered should be included within the cavity outline. This comes in for the greatest consideration when part of the outline is laid on an occlusal surface.

Rule 6. Enamel Eminences.—The outline should avoid extreme eminences of enamel and centers of primary development. Such locations are subject to the extremes of stress during mastication. When the eminence in question is the seat of primary calcification, it will be found to be less perfect in formation than the portion midway from that point to the grooves.

Rule 7. Avoid Angles in Outline.—The outline should be made up of the greatest curves possible, avoiding all angles. Nearly flat axial surfaces should show nearly straight lines or the segments of very large circles, while on occlusal surfaces, which are made up of a succession of depressions and eminences, the outline should be a combination of smaller curves.

Rule 8. Outline in the Embrasures.—The outlines in the labial, buccal, and lingual embrasures should be parallel to each other and at right angles to the seat of the cavity, and pass under the free margin of the gum at a point in full view of the operator.

Rule 9. Enamel Margins.—The enamel margins should be planed smooth to a full cleavage of the enamel rods and then slightly beveled that the rods at the cavosurface angle may be full-length rods, supported by shortened enamel rods which are protected by the overlying filling material.

Rule 10. Extension for Prevention.—When possible, carry the cavity outline from a smooth, unclean surface, an area of great liableness to caries, to an area of lesser liableness to caries.

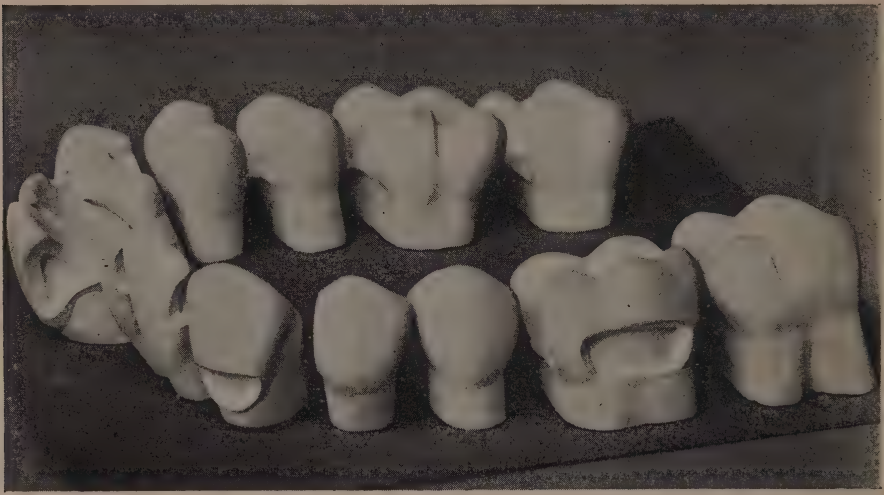

Fig. 17.—Technic group illustrating outline form.

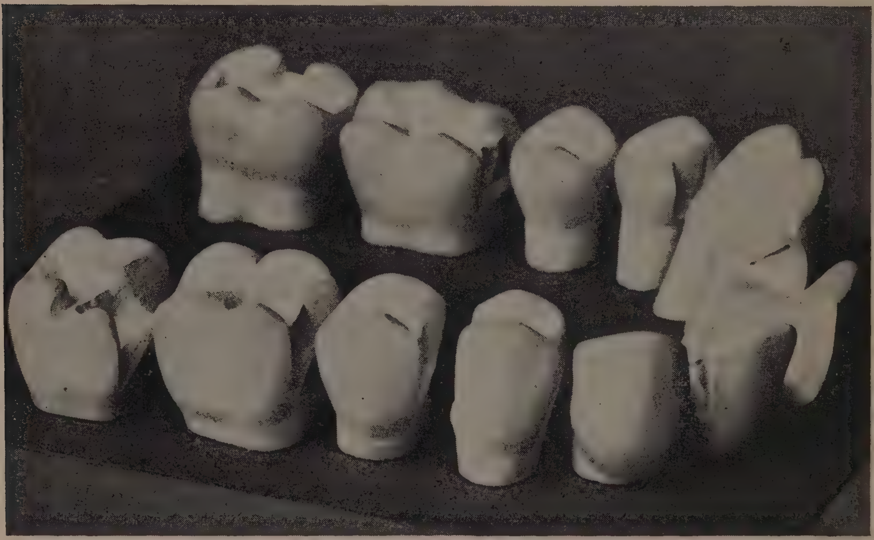

Fig. 18.—Another view of cavities illustrated in Fig. 17.

This has reference to caries of enamel only and will come into consideration in cavity outline when the rules previously given have not carried the outline to comparatively safe and immune localities.

Extension for prevention does not mean the consideration of resistance to stress. It bears no reference to decay of the dentine. It has no relation to the management of frail walls.

Its maximum application is found in the management of small cavities where the ravages of decay have not yet carried the outline of the cavity to areas not subject to primary enamel dissolution.

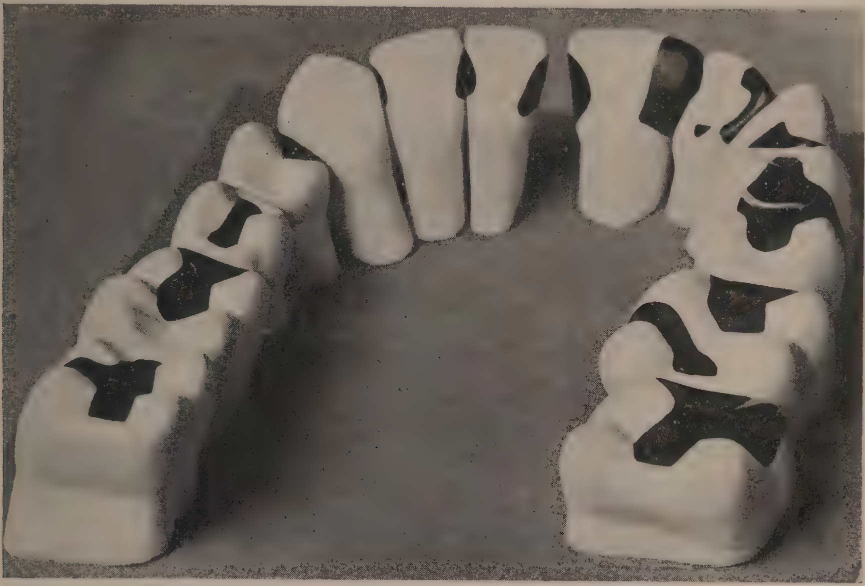

Fig. 19.—Fillings in place in cavities shown in Figs. 17 and 18.

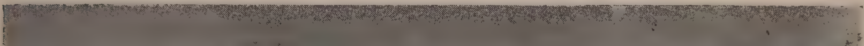

Fig. 20.—Another view of fillings shown in Fig. 19.

The abuses of extension for prevention result in much unnecessary loss of tooth substance, while its sane and legitimate use is one of the most important factors in tooth salvage.

Dangers of Increased Cavity Outline.—The danger of secondary caries increases in each mouth proportionately as the aggregate length of cavity outline is increased.

To Illustrate. If the total length of cavity outline of all fillings in a mouth is doubled by the increase in number of fillings, the liability to secondary caries is doubled, all else being equal. For that reason each individual cavity should have its outline as short as permissible.

The laying of cavity outline in locations not susceptible to primary caries will materially decrease the liableness to recurrent decay, even though the aggregate cavity outline in the mouth is thereby greatly lengthened. An aggregate cavity outline of two feet is preferable to a total of one foot, provided the additional length has been caused to extend to locations not liable to caries.

CHAPTER XI

RESISTANCE FORM

Definition.—Resistance form is the term applied to that portion of cavity preparation which deals with the consideration of the resistance to crushing strain.

Resistance form involves a consideration of the management of weakened enamel walls, the flattening of the seats of fillings, the extending of margins from localities of great liableness to stress to localities of lesser liableness to stress (extension for resistance) and a study of the flow and edge strength of the filling material used with a view to so shaping the cavity as to minimize the effects of crushing strain.

Its importance is in direct proportion to the exposure of the filling in occlusion and articulation, and the strength of the closure of the jaws.

The force to provide for is from 100 to 200 pounds, and in some cases even more, particularly in mid-jaw locations.

Weakened enamel walls are those which, through decay or unnecessary cutting, have been robbed of much of their supporting dentine. All such unsupported enamel should be cut away with a chisel, particularly if, by any chance, the wall of enamel under consideration will receive much stress in the process of mastication.

Stress from within should be avoided by not allowing such weakened walls to remain and form any part of the retention of the filling.

Weakened walls are sometimes allowed to remain, or a portion of them, when they can be so protected by a layer of rigid filling material as to prevent all stress. This is permissible only when their presence will screen unsightly metal fillings and when the kind of filling used can be introduced without injury to the walls.

Flat seats for fillings are imperative in resistance form as applied to stress. Seats should be cut at right angles with the direction of the stress of mastication, which is usually at a right angle with the long axis of the tooth.

As Examples.—In occlusal cavities the pulpal wall should be cut flat, and all of the surrounding walls should meet it at definite angles.

In proximoclusal cavities, where maximum resistance form is needed, the gingival wall should be cut flat in the horizontal plane, with the surrounding walls meeting it at definite angles. The step is also given a horizontal seat in the same plane.

The Step as a Part of Resistance Form.—The addition of the step in cavities of Class Two and Class Four is for the purpose of giving added resistance form as well as retention form. By this procedure in proximal cavities in bicuspids and molars, the stress upon buccal and lingual walls of the cavity proper is transferred to those portions of the same walls which are a part of the step, a location much better situated to withstand the tipping strain. In cavities of Class Four, the addition of the step on incisal, or lingual, or both, will give added resistance form, avoiding heavy cutting at the angle, which usually weakens the remaining tooth substance at the angle to say nothing of the dangers of crossing the horn of the pulp in this location.

Extension of Margins.—The extending of margins which would otherwise be subject to great and frequent stress is most essential. Before applying the rubber dam each case should be inspected for the surface contacted in occlusion and articulation, and then the margin so laid as to occupy the less exposed positions. Many times stress cannot be wholly avoided, but the subject should receive due consideration and good judgment should be exercised.

Properties of Filling Material.—With resistance form must be considered the properties of the filling material to occupy each individual cavity. The greater the amount of flow in a filling material, the greater the internal stress upon weak walls will be; hence, the maximum consideration of resistance form will be found in the use of amalgam.

The greater the edge strength of a filling material, the more protection it will give cavity margins. Yet resistance form should receive scarcely less consideration with those fillings of maximum edge strength.

The amount of marginal extension for resistance form will be less with cohesive gold and gold inlays than with other kinds of fillings.

CHAPTER XII

RETENTION FORM

Definition.—Retention form is that part of the procedure in cavity preparation which deals with the provisions for preventing the filling from being displaced by force. Force is one of the greatest enemies to permanency in tooth filling, second only to recurrent caries.

Partially Provided for in Resistance Form.—Retention form is partially provided for in the previous step of resistance form, but it is further necessary that provision be made to resist the force of mastication in order to prevent the filling as a whole from being moved from its seat.

Maximum retention form is required in cavities in the proximal surfaces of bicuspids and molars (Class Two), as the missing proximal wall renders these fillings particularly exposed to the lateral, or tipping, force during the movements of the mandible.

Maximum retention form is not required when making simple cavities, as such are protected from the dangers of lateral strain by the presence of surrounding external walls. This will be found to be the case in cavities of Classes One, Three, and Five, when occlusion is normal. While in cavities of Classes Two, Four, and Six, much additional cutting is sometimes necessary to give ample retention form.

The stepping of a cavity is for both resistance and retention forms and should be varied to meet the requirements in each individual case.

Flat seats for all fillings is an expedient of resistance form and should be laid, as previously stated, in a plane at right angles to the stress of mastication.

Acute Angles Required.—Much of the retention form required is gained by laying the external surrounding walls at an angle slightly acute to the seat of the cavity.

This has been termed undercutting, but the term is abandoned for fear that some might confuse the method above referred to with a now entirely obsolete practice of creating retention by the use of pits and grooves laid in the dentine walls.

Little Resistance in Enamel.—It should be remembered in this step in the procedure of cavity preparation that there is very little resistance to force in a filling wherein retention form is provided for in enamel walls. The enamel is removed to a depth sufficeint to get anchorage in angles laid in dentine. A good idea of the amount of retention form possessed by any completed cavity may be gained if one will imagine for the time being, that all enamel has been removed from the tooth. The remaining cavity will still have nearly the original amount of retention form. We rely upon the presence of enamel in liable areas for resistance to recurrent caries and upon sound dentine for retention form.

CHAPTER XIII

CONVENIENCE FORM

Definition.—Convenience form is that part of cavity preparation wherein is made those additional changes necessary for the proper placing of a filling.

Sparingly Used.—As these additional cavity changes with the accompanying loss of tooth substance are made entirely for the convenience of the operator, they should be resorted to only in cases of necessity.

Maximum Convenience Form.—The necessity for the use of convenience form reaches the maximum: first, in inlay fillings as the previously prepared filling is moved to position en masse; second, in the making of a cohesive gold filling, as it is of value to apply force as nearly as possible at a right angle to the anchorage of the first portion of gold, and at 12 degrees to all surrounding walls; third, in cavities in the posterior teeth, and in distal cavities as compared with mesial; fourth, more is required for proximal fillings not previously separated.

Minimum convenience form is required: first, in using plastic fillings; second, in anterior oral locations; third, where the teeth have had ample separation before the making of a proximal filling.

The abuse of convenience form is of harm to the teeth and has reached its height in a desire to inlay every tooth possible. When excessive cutting for convenience form is necessary to the making of an inlay, it would be better many times to avoid the unnecessary loss of tooth substance by changing the character of the filling.

Suitable instruments for various locations in the mouth, particularly for the posterior distal cavities, will do much to minimize convenience form.

Previous separation is the most potent factor of all in lessening the amount of cutting for convenience form and should be resorted to in cavities of Classes Two and Three if for no other reason. This has been considered fully in the chapter on ''Gaining Access.''

Starting points for the making of a cohesive gold filling are a part of convenience form. The point angle farthest from the hand when it is in position with the plugger point resting on the cavity is made more acute than is required for general retention. This will be found to be the point angle farthest from view and most difficult to fill, and for that reason should be the first filled. The starting points, therefore, are always made in a point angle at one corner of the seat.

CHAPTER XIV

REMOVAL OF REMAINING CARIOUS DENTINE—FINISHING ENAMEL WALLS—TOILET OF THE CAVITY

Removal of Remaining Carious Dentine

Definition.—This is the secondary consideration of affected dentine. In the smaller cavities the previous steps in cavity preparation will have removed all affected dentine and this step has little consequence. It is well, however, to have this step come to the mind even in these cases, so that the minute corners and obscure localities are not allowed to pass imperfectly prepared.

In large decayed areas the pulp is many times in question. The dentine has been softened near to the pulp. If all of this be removed early in the procedure, the pulp will be exposed to the damaging effects of air drafts from the chip-blower, or possibly low temperatures in the operating room. Pulps thus exposed not infrequently take on the initial stages of destructive diseases from which they never recover, resulting in much pain to the patient and chagrin to the operator. The foregoing is particularly true when making a filling for each of two large proximal cavities.

Two Large Cavities in Approximate Teeth.—It is often desirable to prepare both cavities at the same sitting, particularly when filling with amalgam.

In the cavity first prepared there might be a long exposure of the pulp to lower temperatures if the overlying decayed dentine is removed at the time the major portion is excavated.

Technic.—The remaining decay in this step of procedure should be removed with broad spoon excavators when working on axial or pulpal walls. In small cavities where there is no danger of pulp exposure the instruments should be small hatchets, with which the dentoenamel junction should be examined around the entire cavity. In case a softened area is found and removed, the overlying enamel should be chiseled away, thus restoring the correct outline.

Where exposed pulp is expected or pulp treatment is intended, the decay is removed just following outline form.

Finishing Enamel Walls

Definition.—The last cutting done in the preparation of a cavity is the finishing of enamel walls. This should always be done with the rubber dam in place or at least sufficient means taken to prevent the margins from again becoming moist.

No moisture should be permitted to come in contact with any portion of the cavity surface after final instrumentation, and if, by accident, any portion should become wet, that portion should be thoroughly dried and freshened by cutting away the surface, and the filling immediately placed.

The cavosurface angle of the cavity in every part of the cavity outline should receive special attention at this step in cavity preparation.

The plane of the enamel wall should be so laid with reference to the cleavage of the enamel that there will be more cut from the outer than from the inner ends of the rods, with the result that the last rod at the cavosurface angle will be a full length rod supported by shortened rods. The shortened enamel rods are covered with the filling material when the completed filling is in position.

This is accomplished by a slight planing motion parallel to the external enamel line, using a keen-edged chisel or enamel hatchet. The gingival margin trimmers are especially adapted for this purpose when finishing the margins in the gingival third.

The marginal bevel should be laid in a plane at an angle of from 6 to 10 degrees from the plane of the enamel cleavage.

The depth of the marginal bevel should generally include not more than one-fourth of the enamel wall, but when making a filling of inferior edge strength, such as amalgam, porcelain, cement, etc., it becomes necessary to bury the bevel angle more deeply, or to omit entirely with expanding amalgam and silicate.

Locations subject to great stress also require the placing of the bevel angle more deeply, even carrying it beyond the enamel, laying the bevel angle in the dentine.

Toilet of the Cavity

Definition.—The toilet of the cavity is the final step in the preparation of the cavity and consists of freeing the cavity of all loose particles of tooth substance which are not firmly attached to the cavity walls.

This is best accomplished by a blast of air from the chip-blower, followed by a thorough sweeping and brushing of all surfaces with cotton or spunk held in the pliers, then again using the chip-blower to remove dust.

White enamel margins indicate the presence of loosened enamel rods. If the sweeping does not remove this, the margins should be again chiseled, using a keen-edged instrument and a light hand, then again swept with cotton.

If the whitened margin still persists, they should be brushed over with an extra fine cuttlefish disk or strip or a No. 1 round bur,* when the loosened rods will be carried away.

Care in the Use of Disk or Strip.—It should be fully understood that when a disk or strip is used for this purpose the grit must be so fine that there is no considerable cutting done as there would be danger of changing the relation of bevel to cleavage of enamel.

All Fluids Should Be Used Previous to Cavity Toilet.—The habit of swabbing out cavities with alcohol or other substances after cavity toilet is useless, and may do harm by introducing with the liquid substances not easily removed.

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*Rotating crosswise to the direction of the enamel rods (Woodbury).

Disinfection and pulp protection should have consideration following the removal of remaining decay and as a preliminary step in the toilet of the cavity.

If a fixed oil or an essential oil which may contain impurities has been used, free swabbing and scrubbing of the walls with alcohol or spirits of chloroform is advised for cleansing purposes, to get rid of the oil and other residue. Simply wiping the cavity out, however, will not suffice. It must be thoroughly rubbed with an alcohol- or ether-moistened cotton ball, followed by reasonable desiccation from the chip-blower, and then every part of the walls and margins gone over and freshly cut. This is the only means of obtaining a clean surface.

Leaks in the rubber dam, particularly near the gingival outline, must positively be detected. The portion which has become wet should be dried with an absorbent and the air blast. Then all parts which have been moistened must be gone over and freshly cut. Simply drying such portions is not adequate, as there are left salts and albuminoids from the saliva and blood serum which can be removed only by the cutting instruments. The placing of a filling over this gummy residue invites secondary caries. These deposits will subsequently dissolve, resulting in a leak. It may be small but the acid of tooth decay will easily exchange places with such films.

If the cleaning has been fairly well done, it may result only in what is termed blue margin.

When time intervenes between cavity preparation and the making of the filling, as from one sitting to another, the walls and margins should be retrimmed to give freshly cut surfaces to fill against. This is not possible in the making of inlays, as to retrim the margins destroys the fit. The fact that many times we cannot place the inlay against surfaces which have been freshly cut constitutes the greatest enemy to their permanence.

It is the one great argument for the making of inlays at one sitting and under dry conditions.

Conclusion.—All fillings should be made against clean, freshly cut walls.

CHAPTER XV

MANAGEMENT OF PIT AND FISSURE CAVITIES (CLASS ONE)

Location.—Class One cavities occur in the occlusal surfaces of molars and bicuspids, in the middle and occlusal thirds of the buccal and lingual surfaces of molars, and in the lingual surfaces of incisors, more frequently the lateral. (See Figs. 21 and 25.)

The predisposing cause of decay in these localities is a fault in the enamel due to imperfect closure of the enamel plates, affording a convenient point for the lodgment of food particles and the active agents of fermentation, which are the exciting cause of all tooth decay.

Extension for prevention is seldom necessary in this class of cavities from the fact that the surface of the enamel in the immediate neighborhood, is exposed to the friction of mastication.

Tendency to extensive dentinal decay must be remembered in dealing with this class of cavities, as the merest opening through the enamel will frequently, upon excavation, show an extensive loss of dentine.

Incipient Decays in Occlusal Defects

Description.—Upon examination it is found that the tine of a sharp explorer will pass between the nonunited plates of enamel to the depth of the entire thickness of enamel in one or more points. A more careful examination may show the surface of the dentine to be softened to a greater or less extent immediately pulpwise from the enamel fault. Such cases demand immediate attention.

Outline Form.—To open such cavities there is placed in the engine a discarded No. ½ or 1 round bur which has been made into a spade drill by flattening on two sides. This drill is made to travel between the plates of the enamel through a major portion of the defect, thus widening the fissure. This preliminary step will result in much saving of burs, as a bur which has once been used on an enamel wall is unfitted to cut dentine. The common practice of using dentate fissure burs for this work is considered as brutal to the patient and is a thief of the operator's time. A No. ½ or 1 round bur is now used in the engine and applied to the dentine. By swaying the hand piece to and fro the dentine is cut away from beneath the enamel walls. The bur should be removed frequently to permit cooling, as heat develops readily and is a great and frequent source of pain to the patient.

The use of the chisel is next advised for the removal of the overhanging enamel wall; first, because this is the easiest and speediest means of its accomplishment, and second, because this is the only means of securing the cleavage of the enamel, giving the operator the opportunity to judge the amount of resistance to stress in the several localities and to learn the direction of the enamel rods. Many times a chisel-edged hatchet will be most advantageous, one which has a chisel edge upon the sides of the blade as well as the cutting edge. The size should be governed by the size of the opening secured, but in every case as large an instrument as the orifice will admit should be used. This process should be repeated with bur for cutting dentine and chisel or hatchet for cleaving enamel until the desired cavity outline is obtained.

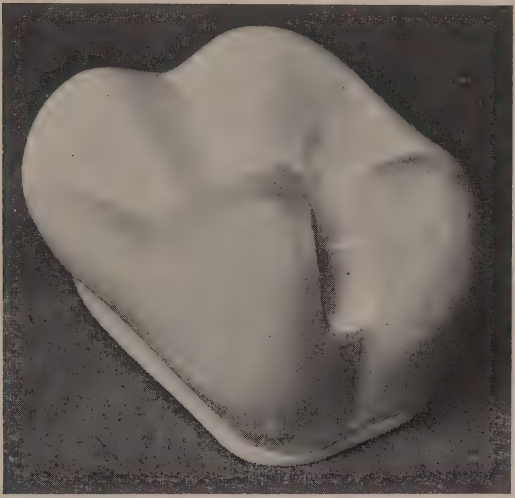


Fig. 21.—Complex Class One cavity prepared.

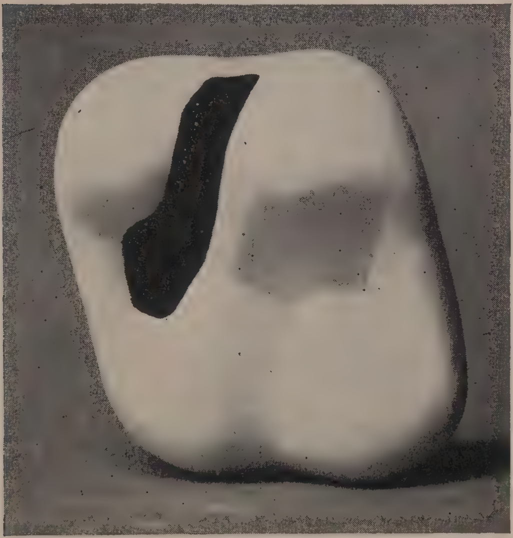


Fig. 22.—Class One filled. Cavity shown in Fig. 21.

Resistance Form.—The operator should include all fissure and sulcate grooves. Cross all grooves and ridges at as near a right angle as possible. Avoid eminences of primary calcification. Lay the outline as much as possible along the sloping sides of the triangles and ridges, as these are the most favored localities for a cavity margin, for on these sloping surfaces we find the greatest amount of friction during the process of mastication, due to the excursions of food, and they are the least exposed to direct stress as the blows are of a glancing nature.

Retention Form.—Here is a good rule to follow in cavities of Class One. When the depth of the cavity is equal to or greater than the width, parallel walls are sufficient. But when the width exceeds the depth, the external walls should meet the internal wall at a slightly acute angle. These angles are best made acute by the use of a chisel-edged hatchet or hoe, having corners that are slightly acute. With a planing motion they should be made to travel parallel with the base line angles. This will, at the same time, flatten the seat or pulpal wall. The extreme ends of long arms in a filling, such as that which results from following a slender fissure, must be made retentive.

Convenience Form.—No convenience form is usually necessary in small cavities of Class One, except in rare instances it may be of advantage to sharpen one of the distant point angles to facilitate the starting of a cohesive gold filling. But usually the first portion of gold used may be of sufficient size to entirely cover the pulpal wall, in which case it can be securely locked to position between the surrounding walls.

Removal of Remaining Decay.—By this time the carious dentine will usually have been removed. Should any remain it should be excavated with suitable spoons.

At this point there should be a thorough inspection of the dentoenamel junction for small areas of softened dentine which may have escaped notice.

The walls should all be flat, particularly the pulpal. In cases where decay has progressed so deeply into the dentine that to flatten the pulpal wall would cause the involvement of the recessional tracts of the horns of the pulp, the base line angle should be made intermittent, omitting the squaring of the angles in the regions of the recessional tracts.

Disinfection.—The cavity should be flooded with alcohol carrying a small amount of formaldehyde, say 1 or ½ per cent, and evaporated to dryness.

Finish of Enamel Walls.—The enamel wall should be planed for the entire outline of the cavity with a sharp chisel using a light hand, the desired cavosurface angle secured, and the bevel angle buried to the desired depth. The movement of the chisel should parallel the travel of the external enamel line.

Toilet of the Cavity.—The cavity should be swept with a tightly rolled cotton ball or piece of spunk in the pliers and the dust finally removed with a blast of air from the chip-blower, and the filling immediately placed.

Inlays.—If the cavity is to be occupied by an inlay, retention form may have been omitted and applied to the cavity just before setting the filling, in which case the toilet of the cavity should be repeated. If the cavity has already been given retention form, the same should be temporarily removed while making the model, by wiping into the retaining angles wax, temporary stopping, or cement, to be removed before final placing of the filling.

CHAPTER XVI

MANAGEMENT OF PIT AND FISSURE CAVITIES (CLASS ONE, CONCLUDED)

Large Cavities in Central Fossa of Molars

Description.—Such cavities are usually the result of knowing neglect on the part of the patient. In cases, however, where the enamel is strong and of a good resistant quality, or the teeth are so occluded as to have received little stress, the patient may be in ignorance of the great havoc which has been done, due to the major portion of the enamel remaining intact. There may exist in such cases only the slightest aperture through a defective fissure or fault in the enamel.

Outline Form.—This division of Class One cavities should be opened with a straight or binangle chisel of rather large size to prevent easy passage to the sensitive pulpal wall. A chisel of two to three millimeters in width is advised. The securing of adequate finger rest on adjacent tissues is important. The chisel should be applied so as to throw the chips into the cavity, and the mallet substituted for heavy hand pressure. It is best to begin on margins most mesial, and nearest the operator's eyes, as this increases the range of vision to the deeper portions of the cavity at an early stage in the procedure. This chipping away of the enamel should be continued until enamel supported by sound dentine is reached and until the margins have been carried to desired regions, as set forth in general in the chapter on outline form.

When Pulp Exposure Is Feared.—In this case the sixth step in cavity preparation will come in third, and we have for consideration the removal of remaining decay.

Up to this point only the most superficial examination of the internal surfaces has been made.

Placing the rubber dam at this point is expedient as dryness is imperative. The decay is now removed with large spoon excavators, whose blades are at least two millimeters wide. These spoons, which should be keen of edge, are carefully worked under the edges of the masses of softened dentine, and by a prying, sweeping movement this is lifted en masse from the walls. The blade of the excavator should be prevented from scraping, or sliding over the regions of suspected exposure.

When the pulp is exposed or nearly so, the operator will proceed to pulp treatment, either pulp capping or partial pulpectomy, as the case demands. This step completed, outline form is again taken up and the fissures and sulcate grooves included in the cavity outline.

Resistance and Retention Forms.—As to resistance, we have only to consider the probable stress to be sustained by the filling as a whole and by the margins in their various localities. This will involve a study of each case in hand as to occlusion and articulation, as well as to habits of the patient in mastication. The problem of concave pulpal wall is here met in its most exasperating form. Many times if the operator were to take the lower levels of the pulpal wall and attempt to flatten and carry this wall laterally until it could be made to meet surrounding walls at different angles, the recessional tracts of the pulp would be crossed and exposure of that organ would result.

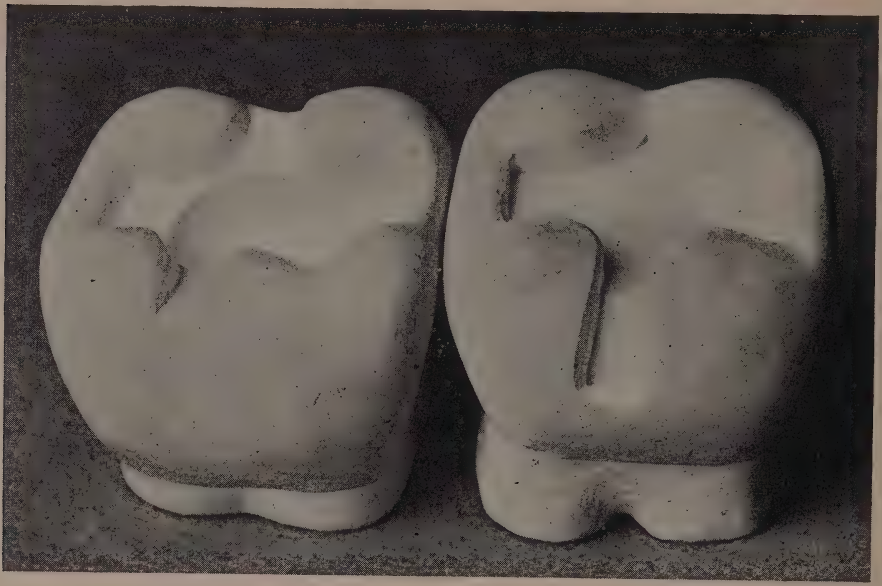


Fig. 23.—Large Class One cavities prepared.

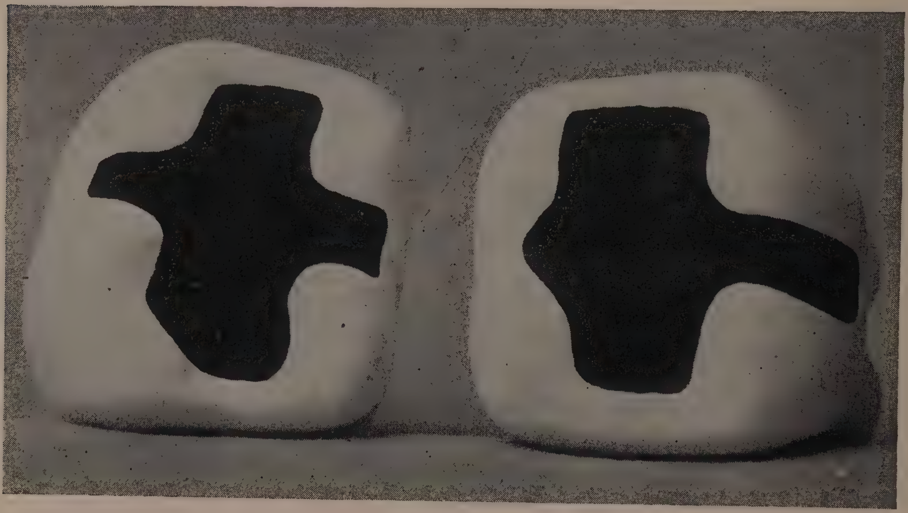


Fig. 24.—Class One filled. Cavities shown in Fig. 23.

The Flattening of the Pulpal Walls Avoided.—(See Fig. 23.) This lateral cutting to flatten pulpal walls may be avoided in two ways:

First, the operator may establish a level higher up on the lateral walls for the creation of the base line angles, resulting in steps. These steps should be established in places most remote from pulp recessional tracts. This will generally be found to be in the neighborhood of developmental grooves. There should be at least three of the steps or small supplemental seats. Four-point suspension is better. As the seats are small and will probably be required to carry relatively heavy loads, their angles should be most definite.

Second, to avoid the flattening of these pulpal walls in large cavities of this class the operator should build the metal portion of the filling immediately into cement which has been applied to the pulpal wall. This renders the base of the filling adhesive to its seat and nullifies the tendency of the filling to slip or revolve under load.

The principle of the inlay is thereby introduced into the built-in filling, a much valued feature by many operators.

Convenience Form.—There is no convenience form required in this class of cavities when making a plastic filling. In the making of a cohesive gold filling in these cavities, care must be taken that the mesial wall can be reached by direct force from the plugger point. In some cases it will be necessary to move the mesial margin well upon the mesial marginal ridge to accomplish the desired result.

Convenience point for the beginning of the first pieces of gold should be obtained through the use of a small quantity of thin cement applied to the deepest portions of the cavity.

Finish of Enamel Walls and Toilet.—The cavity should be phenolized and the same evaporated to dryness. The entire cavity outline should be freshly planed, the margins slightly beveled, and a positively determined cavosurface angle established. The depth the bevel angle is to be buried should be determined.

The cavity should be thoroughly swept with cotton, the dust dissipated with a blast from the chip-blower, and the filling immediately placed.

Pit Cavities in Buccal and Lingual Surfaces of Molars

Description.—These cavities have their origin in defects in the enamel on the buccal surface of lower molars and the lingual surface of upper molars.

Instrumentation is the same for the class and size of cavities just described on the occlusal surface, unless perhaps it may be necessary to use the engine burs in the contra-angle hand piece, a necessity seldom met with on the occlusal surfaces.

Outline Form.—The outline should be carried well out of the pit or groove and sufficiently extended to meet the general rules given in the chapter on this subject.

Resistance form will come up for consideration only when the outline approaches the occlusal marginal ridge. In such cases if the occlusal wall is not made up of a sufficient bulk of dentine to withstand the stress of mastication, the outline should be carried over the marginal ridge to the occlusal surface, in which case rules for the outline of this portion of the cavity will be the same as previously given and applicable to all cavities invading occlusal surfaces.

Extension for prevention will come in for consideration when the outline has, for other causes, been brought near to the free margin of the gum. A full application of the rule "Extension for prevention" would demand that the gingival outline be carried under the free margin of the gum when the gum has already been approached to within one millimeter. A failure to extend the outline is permissible in mouths kept scrupulously clean.

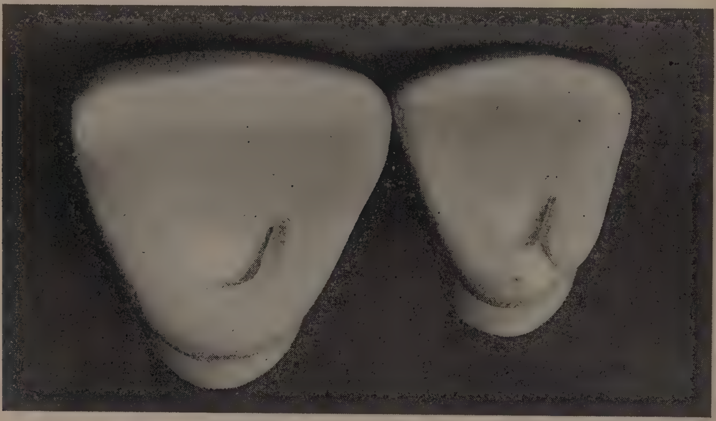


Fig. 25.—Lingual pit cavities.

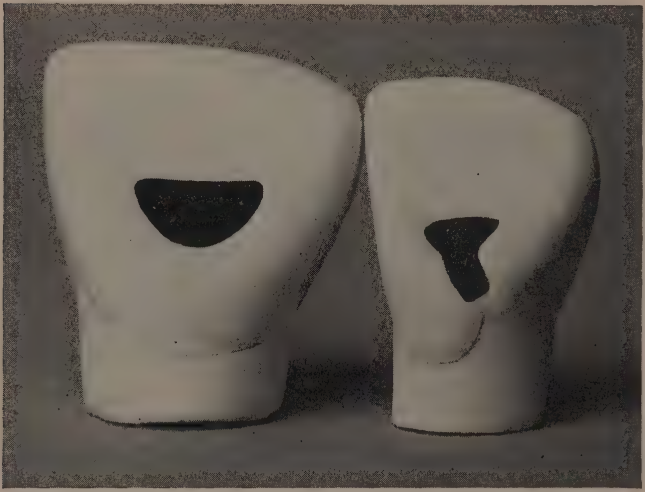


Fig. 26.—Class One filled. Cavities shown in Fig. 25.

Retention Form.—This step is very simple when the cavity does not involve the occlusal surface and is fully obtained when the internal line angles have been well squared. When the cavity reaches the occlusal surface, however, the filling is subjected to the greatest amount of tipping strain in mastication. These will then demand a flat gingival wall, and, in some cases of a vital tooth, a flat pulpal wall placed parallel to the gingival wall, with the line angles surrounding these walls well defined. The four point angles should be slightly acute.

Finish of Enamel Walls.—In the management of these axial surface pit and fissure cavities, the varying slants of the enamel rods should not be lost sight of. This should be noted when outlining the cavity with the chisel. The rods, close to the defect, will generally be found to incline toward the pit from every direction, while a little way out they will be found at right angles to the surface.

Going farther toward both the occlusal surface and the gingival line, the outer ends of the rods will be found to incline more and more away from the seat of decay.

These facts should be borne in mind and a full cleavage obtained.

There now remains only the usual marginal bevel and cavity toilet.

Pit Cavities in Lingual Surfaces of Upper Incisors

Early Attention.—These cavities should be detected in their early stages as their near location to the pulp renders pulp complications an early sequence.

It is the best of practice to permanently fill all cases presented where faults in enamel are diagnosed.

Instrumentation.—Their location renders excavation hazardous. The engine bur should be used for superficial opening only, most of the preparation being done with hand instruments.

Outline Form.—The general rules in outline form should be observed. Particular note should be made of the extreme incisal inclination of the outer ends of the enamel rods along the margin of the incisal wall.

Incisoaxial Line Angle.—It is generally advisable to allow the incisal wall to meet the axial at quite an obtuse angle, in some cases almost to the obliteration of this line angle, as the squaring of this angle will greatly endanger the pulp.

CHAPTER XVII

MANAGEMENT OF PROXIMAL CAVITIES IN BICUSPIDS AND MOLARS (CLASS TWO)

Location.—Class Two cavities are those which originate on the proximal surfaces of molars and bicuspids at a point slightly gingival from the point of contact.

Predisposing Cause.—The predisposing cause is the presence of the adjoining tooth, which establishes and maintains a sheltered position for the accumulation of substances which undergo fermentative decomposition.

Early Detection of These Cavities Is Essential.—It is of the utmost importance that Class Two cavities be discovered early. More pulps are lost to the teeth from the neglect of these cavities than from any other cause. Their early detection is by no means an easy matter to the inexperienced operator, as often their presence is shown only by a change in the color of the overlying enamel.

There are yet other cases where the teeth must be separated for an examination of the suspected surfaces.

It requires education in the use of the explorer to detect the difference in the ''feel'' of the explorer tine in the proximal space and the entry of the point into a cavity of slight depth. When the decay has extended along the dentoenamel junction, the case becomes much easier and should never escape the detection of the operator.

Small Proximal Cavities (Class Two)

Description.—By examination there is found to be established an area of decay upon the enamel surface between the contact point and the free margin of the gum, on one or both teeth which go to form the space in question. The dentine may or may not be involved. The marginal ridge is still intact and firm. The enamel shows no signs of injury in either the buccal or lingual embrasures. (Molar, Fig. 28.)

Gaining Access.—Opening the cavity is often the most difficult step in the procedure.

There are three plans of procedure open to the operator.

The First Method.—The one most common and often the best is to place the angle of a sharp, straight chisel, say one millimeter in width, on the proximal slope of the marginal ridge and tap it lightly with a mallet; turn the other angle so that the chisel edge rests at 45 degrees to the position of first impact and again apply the mallet. Repeat several times and this will generally break away the enamel rods in a small V-shaped space. This may be continued until the cavity is completely uncovered. In comparatively resistant cases the bibeveled drill may be applied to break in the enamel.

The second method of procedure is to use the bibeveled drill in the mesial or distal pit, giving the hand piece that slant which will cause the drill to enter the area of decay, when sufficient depth has been reached. The chisel is then applied and the occlusal surface enamel cleaved away either by hand pressure or by the mallet. This method is more liable to cause pain than the first given and should be used with caution.

The third method is to adjust the mechanical separator and attack the enamel with a small chisel from the buccal direction, gradually shifting more and more to the occlusal surface, until finally the enamel ridge gives way to the force of the chisel.

Preliminary separation should in most cases, be resorted to for proper access. The many reasons for this are set forth in Chapter IX.

This is best accomplished at this stage by packing the cavity with gutta-percha for a few days or weeks. When the patient returns, the operator should be ready to consider outline form.

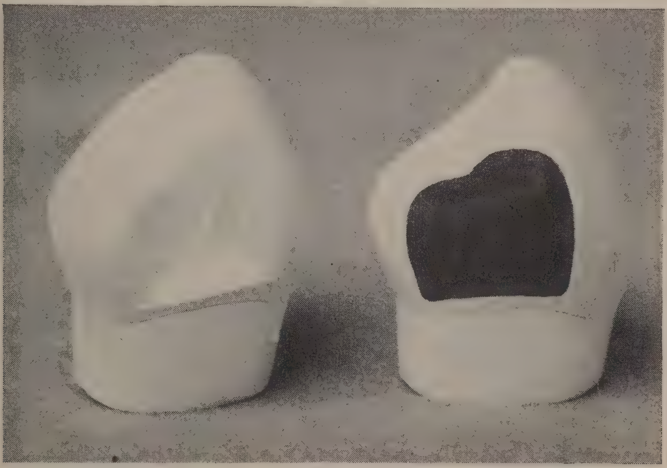


Fig. 27.—One of the few cases in which the step may be omitted in Class Two cavities.

Outline Form.—Outline form in Class Two involves the outlining of the cavity proper, as well as the outlining of the occlusal step, which is generally necessary because of the more secure seating and rigidity it gives a filling in all proximoclusal cavities in molars and bicuspids when the marginal ridge has been broken.

Step May Be Omitted. First, in cases which are to remain permanently disarticulated, as when the opposing tooth has been lost.

Second, when the proximating tooth is to be absent permanently, thus obviating much cutting buccally and lingually in extension for prevention, as the remaining walls are sometimes strong enough to give sufficient resistance form without the added step.

Third, in the proximal decays in the gingival third following excessive gum recession (so-called senile decay).

Fourth, when, for any reason, the patient should be shielded from long operations, or the life expectancy of either the patient or the individual tooth is short.

Fifth, in that form of lower bicuspids with a well-defined and perfect transverse ridge. (Fig. 27.)

Outline of Cavity Proper.—The outline should be carried into both buccal and lingual embrasures until the excursions of food through these embrasures will sweep the margins of the completed filling for its entire length. This extension will result in carrying the outline out sufficiently for it to be seen to pass under the gum in full view.

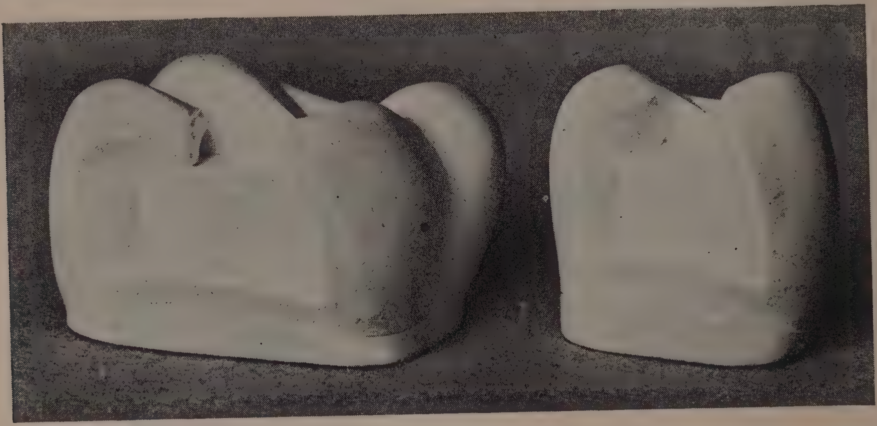


Fig. 28.—Class Two cavities in molar and bicuspid, suitable for cohesive gold or amalgam.

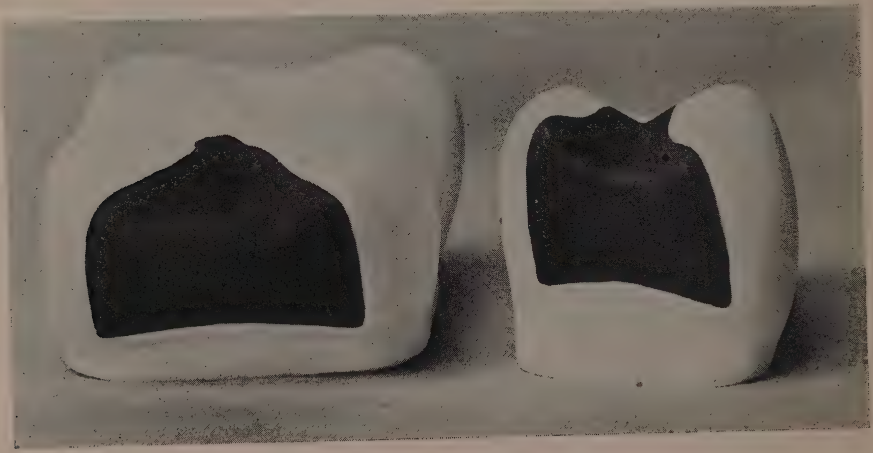


Fig. 29.—Class Two filled. Cavities shown in Fig. 28.

A good rule to follow is to cut sufficiently for a chisel one millimeter in width to pass easily from the embrasures to the open cavity when dragging the cutting edge lightly over the free margin of the gum. This is stated as a general rule only, there being circumstances which would permit falling short of this amount of space, and cases which demand a greater amount of cutting to fully meet the requirements of extension for prevention, due to oral conditions and dental irregularities.

Extensions Gingivally.—The cavity outline should be carried subgingivally in extension for prevention when, for other reasons, that part of the outline approaches to within one millimeter of the gum line. The application of this rule will invariably cause the outline to go beneath the gum in case the gum either is in or resumes its normal position.

If there is reason to believe that it will return to its normal position, this fact should be considered. In cases of permanent recession it is better to stop the cavity outline midway from contact to gum line.

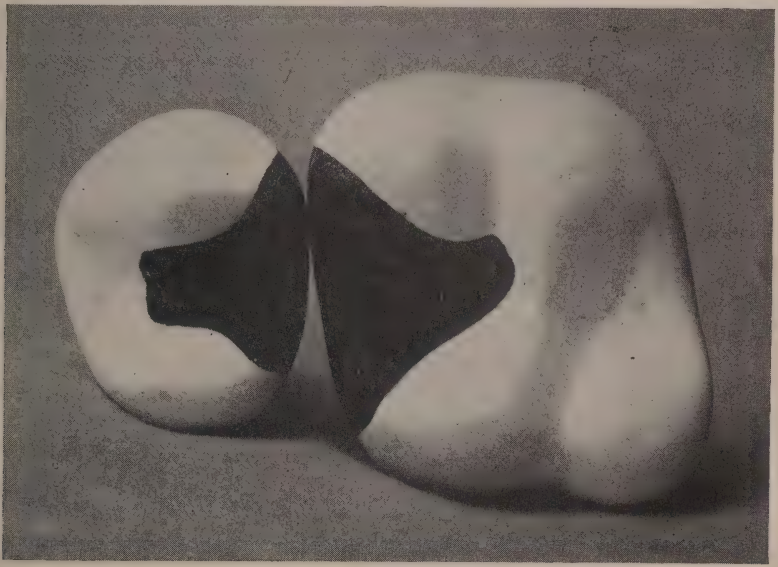


Fig. 30.—Fillings shown in Fig. 29 contacted, illustrating the marble contact.

Care at Axiogingival Angles.—The buccal and lingual portions of the outline should be carried directly gingivally and be made to join the gingival portion of the outline by the use of a segment of a small circle. The use of a large circle here is a most common error. Investigation of fillings will show many failures wherein a large circle has been used, allowing the external outline to disappear in the proximal space before it has disappeared beneath the gum.

The gingival outline should be a straight outline except in well-defined and high gum festoons, when it may be made convex to the occlusal surface.

Forming the Step.—Place a small round bur or spade drill against the axial wall at the dentoenamel junction, immediately below the central fissure, and undermine the enamel for the desired distance in the direction of the central axial line of the tooth. Here apply all of the rules and methods of procedure given in the formation of a simple occlusal cavity. Also remember to apply the rules as given in outline form, particularly as to resistance form.

Area Included.—In addition to the above, it is a safe rule to state that the step portion should involve the central third of the occlusal surface buccolingually.

Avoid all angles in outline. Care should be taken, when using the step, that its union with the cavity proper does not show in the outline by an angle at their junction. Also, when not using the step, as in the few cases cited, care should be taken to prevent the axiobuccal and axiolingual line angles from meeting the external enamel line. These line angles should be stopped before they approach the enamel wall.

Resistance and Retention Forms.—To reach the maximum of these forms it is necessary that the *gingival wall* be flat and laid in a plane at right angles to the stress of mastication. The gingival wall should meet the axial wall at an angle slightly acute.

The grooving of the gingival wall is condemned.

The buccal and lingual walls should be flat, parallel, should meet the gingival wall at least at right angles, and the axial wall at definite and acute angles.

The axial wall should be convex to the proximal space and should meet the pulpal wall in a rounded pulpoaxial line angle.

The pulpal wall should be laid parallel to the same plane as the gingival wall, and slightly broader at the portion most distant from the cavity proper. This gives a pulpodistal or pulpomesial line angle of a little greater length than that of the pulpoaxial line angle, resulting in a dovetailed effect that is most efficient.

Line Angles.—The line angles should be squared out and made definite by the use of small hatchets and hoes of suitable shapes to reach the desired localities.

The gingivobuccal and gingivolingual line angles should extend from their corresponding point angles to the dentoenamel junction. The axiobuccal and axiolingual line angles which arise in the same point angles should travel occlusally one-third to one-half the height of the axial wall. In some rare cases where the pulpal wall is low from decay, these line angles may meet the axiopulpal line angle. A failure to observe this rule endangers the pulp through a liability of crossing its recessional tracts.

Convenience Form.—In the making of a cohesive gold filling, a convenience point for the retention of the first piece of gold is desirable. This is best accomplished by employing a small inverted cone bur, say No. 33½.

The flat face is placed on the gingival wall and first sunk to one-third its depth, then drawn for a short distance occlusally along the axial line angle, taking dentine slightyl at the expense of both axial and external walls.

With the making of a plastic filling there is no need of cutting for convenience form in this cavity.

Inlays.—When using an inlay, proper convenience form is obtained by thorough separation and by causing the external walls of both step and cavity proper to meet the gingival and pulpal wall at slightly obtuse angles. This will give draw to the occlusal.

Finish of Enamel Walls.—The enamel walls are planed to full cleavage and the margins are slightly beveled. All but the gingival margins may be done with the chisel. Special instruments are required to bevel the gingival cavosurface angle, known as gingival marginal trimmers. These are made rights and lefts for mesial cavities, and rights and lefts for distal cavities, and should be on hand in two sizes, which would result in eight instruments in a good working set.

In planing the gingival enamel wall the operator should have in mind the gingival inclination of the enamel rods in this locality.

Toilet of the cavity should now be made and the filling immediately placed.

CHAPTER XVIII

LARGE PROXIMAL CAVITIES ENDANGERING THE PULP (CLASS TWO, CONCLUDED)

Description.—This class of cavities shows, when presented, extensive loss of dentine in the proximal wall. The marginal ridge may be standing or it may have been broken through stress of mastication. In some cases there may be an occlusal decay in the central fossa.

Danger of Pulp Exposure.—There is always great danger of pulp exposure in these cases and this fact must be continually borne in mind during the procedure of preparation. The likelihood is increased when the patient is young or the cusps of the tooth are high, particularly when there exists a deep pit cavity in the occlusal surface necessitating a low pulpal wall. With young patients the pulps are large and the horns of the pulp generally extend well toward the cusps. Teeth with high, prominent cusps usually have long pulp horns, which should be considered in making resistance, retention, and convenience forms.

Outline Form.—The first cuts in this class of cavities should be made with the chisel, using hand pressure, being sure that adequate hand and finger guard has been obtained. This precaution is essential as the chisel must be prevented from reaching the sensitive softened dentine within the cavity Place the chisel so as to throw the chips into the cavity. The chisel should be made to engage only a small portion of enamel at each cut. Should the enamel prove resistant, the aid of the mallet may be resorted to, still maintaining a firm finger rest.

Extension for prevention is frequently not necessary as the extension necessary for proper resistance form will carry the cavity the required distance into both buccal and lingual embrasures. In many cases, however, the decay will be found to have progressed more toward one embrasure than the other, which necessitates additional cutting for prevention in the direction of the embrasure least approached by decay. This should be done to the fulfillment of the rule for "extension for prevention."

Gingival Outline.—The gingival outline in these cases will generally be under the free margin of the gum. At this stage it should be planed with the enamel hatchets until the overhanging enamel is broken away to give access form for the free passage of the dam and ligature which should now be placed, after which the cavity should be superficially sterilized.

Occlusal Outline.—When the cavity has been rendered dry, the occlusal outline should be proceeded with. This is carried out as previously given in the forming of the step portion, and to the full satisfaction of the rules given on outline form in Chapter X.

Removal of Remaining Decay.—This is an instance where the sixth step in cavity preparation comes third and should now be proceeded with cautiously.

Technic.—Large spoons should be used. The softened and discolored dentine should be lifted from its position with as little pressure pulpwise as possible. If exposure exists upon its removal, pulp treatment for devitalization and removal is the immediate procedure. If exposure does not exist and the operator has reason to believe that that organ is healthy, the pulpal and axial walls should be lightly scraped with large spoon excavators, the walls disinfected with the favorite drug, then dried, phenolized, and dried again, the latter precaution to prevent thermal shock to the pulp during the remaining portion of cavity preparation, the imperative necessity for which is shown when pain is induced by a blast of air from the chip-blower.

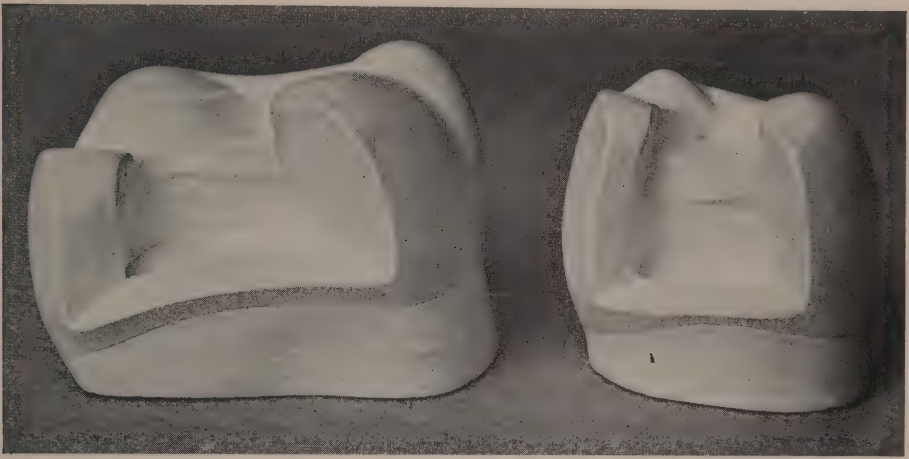


Fig. 31.—Large Class Two cavities in nonvital teeth, restoring part of the occlusal surface for the protection of weakened walls.

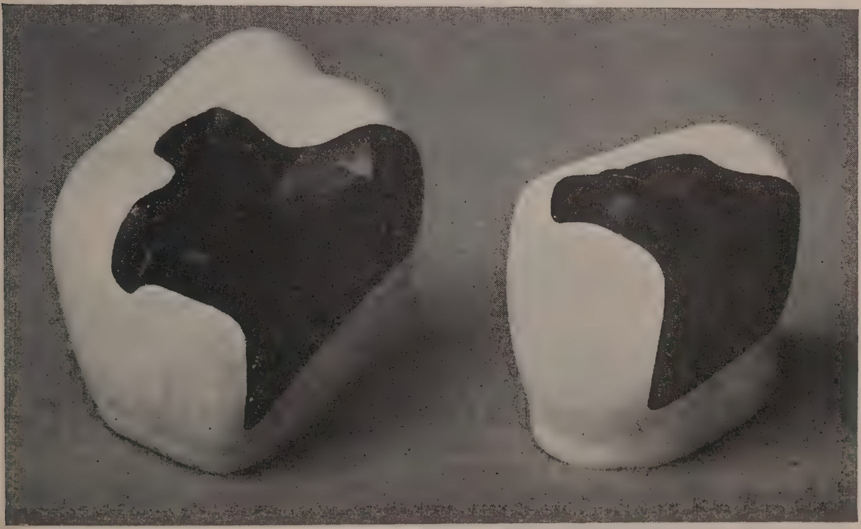


Fig. 32.—Class Two filled. Cavities shown in Fig. 31.

Resistance and Retention Forms.—When the central portion of the decay is found to be deep, and no exposure exists, the pulpal and axial walls should be left in their central portions much as decay has left them, no attempt being made to flatten these walls on a plane of their greatest depth, as pulp exposure may result. The line angles surrounding these two walls should be established on higher levels.

The gingival wall should be made flat in every direction. This is accomplished by lowering the point angles rootwise to the level of the central portion.

Convenience Form.—Every part of the cavity should be examined to see that it is accessible to direct force in the packing of the filling and a convenience point cut in each of the gingivoaxiolingual and gingivoaxiobuccal point angles.

Pulp Protection.—The cavity should be flooded with an efficient nonirritating disinfectant, dried, phenolized, and dried again. If the pulp is in danger, it should be protected as described in Chapter XXXVII.

Finish of Enamel Walls

The enamel walls should now be inspected, corrected for complete cleavage, and the proper cavosurface angle established, using for this a keen-edged chisel and a light hand with a planing motion parallel with the external enamel line.

For toilet of the cavity use a few blasts of air from the chip-blower, followed by a thorough brushing with a ball of cotton and more air blasts. The filling should be immediately placed.

Large Proximal Cavities in Nonvital Teeth

In the management of this class of cavities, cutting for resistance to stress reaches the maximum, and outline is many times materially extended for this purpose alone.

Outline Form, With Molars.—All decay and softened dentine is removed. Often this will leave standing an entire cusp of unsupported enamel and possibly both proximal cusps are thus unsupported. In such cases a thin-edged carborundum wheel is placed on the occlusal surface and this surface is ground away for one or two millimeters, extending toward the central axial line to just beyond the buccal or lingual groove, or both, when both cusps are to be removed. This grinding process is carried to a greater depth in the region of the groove, resulting in a step which gives the filling an occlusal surface seating.

With bicuspids this buccal or lingual outline is carried past the crest of the cusp involved and partially down the opposite slope. This procedure results in disarticulating the frail enamel wall and so placing the metal that it will receive the force of mastication.

In mesiodistoclusal cavities in both bicuspids and molars, with vital pulps and when using cohesive gold as a filling, the occlusal outline should include all of the middle third buccolingually. It should be made sufficiently deep to remove all of the enamel in the central fissure.

For cohesive gold the buccal and lingual walls should be parallel and without retention as the retentive form should be placed low in the gingival angles of both mesial and distal cavities.

In the use of amalgam, the outline should be farther extended buccolingually, to include about one-half of each of the buccal and lingual thirds.

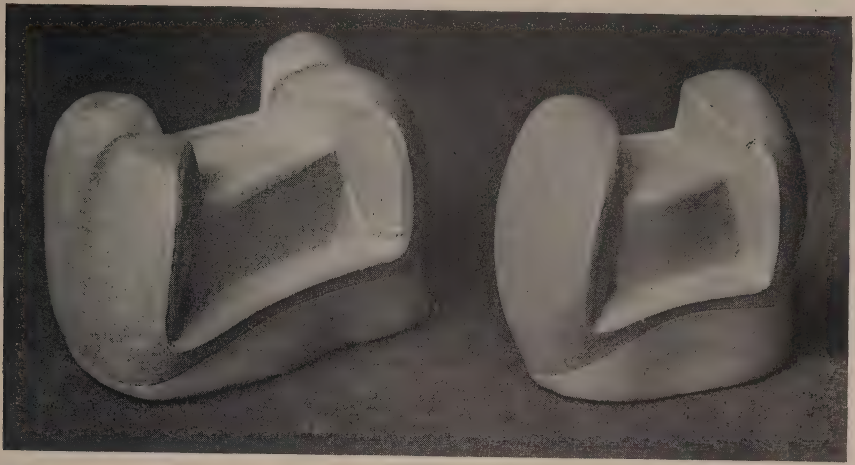


Fig. 33.—Mesio-occlusodistal (M.O.D.) cavities in molar and bicuspid, vital pulps. Note that the occlusal portion of the cavities does not show any retentive form. It is not necessary to undercut these walls as there is ample retention in other parts of the cavity.

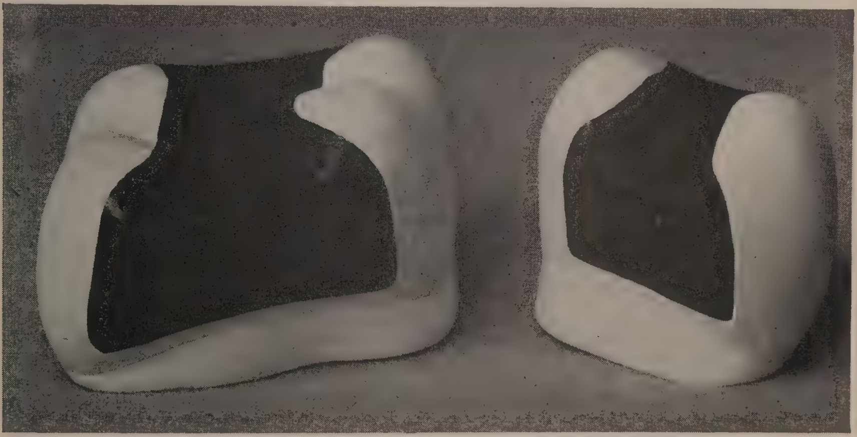


Fig. 34.—Mesio-occlusodistal fillings. Cavities shown in Fig. 33.

Thus, two-thirds of the occlusal surface buccolingually will be filling. This occlusal portion should be without retentive form, with the buccal and lingual walls meeting the pulpal wall at angles slightly obtuse. This is the minimum amount of extension for favorable cases with vital pulps.

In cases of extreme frailty the entire occlusal surface of molars and bicuspids should be replaced with filling of at least one millimeter in thickness. With upper molars and bicuspids, when nonvital with very frail mesio-occlusodistal cavities, the lingual cusps should be removed for one or two millimeters and replaced with filling material.

Retention form is completed by squaring up the side walls and subpulpal wall, making a box shape of the pulp chamber, with fairly definite point angles.

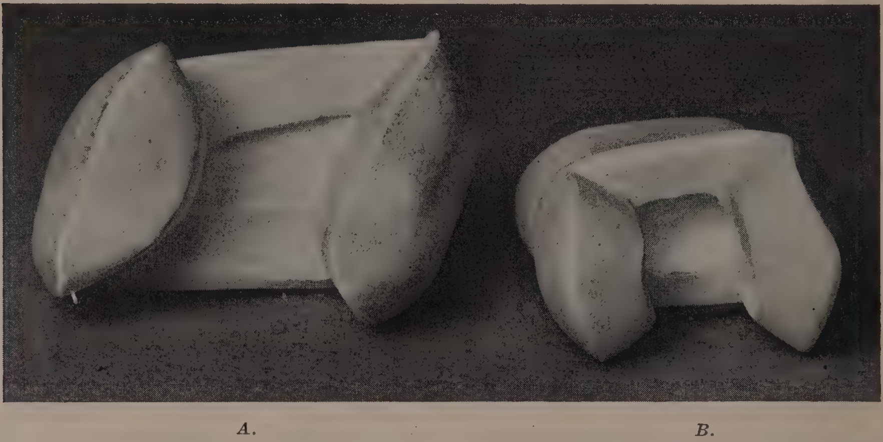


Fig. 35.—*A*. First superior molar, pulpless, restoring the lingual cusps. *B*. Second superior bicuspid, pulpless, restoring the entire occlusal surface.

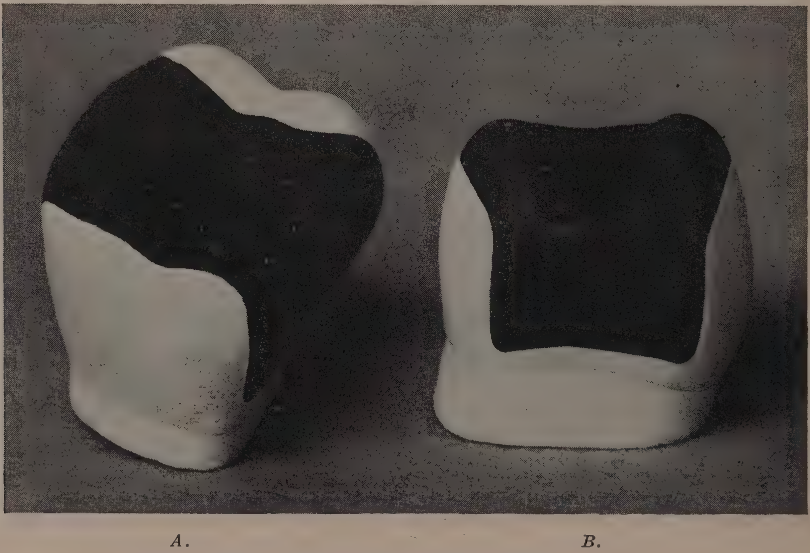


Fig. 36.—Class Two filled. Cavities shown in Fig. 35.

Screw-Post Anchorage.—Additional anchorage may be secured by setting a headed screw-post in cement in one or more of the pulp canals. When only one post is to be used, the largest root should be selected for the post. Be sure by radiographic diagnosis that that particular root is not diseased.

Sectional Fillings.—In cases where the mesial and distal outlines are extrasubgingival, it is many times of advantage to build an amalgam filling in sections.

The first section is built well above the gum line and the patient is dismissed. At the next sitting the portion of the filling previously built is polished on its external surfaces, paying particular attention to the cavity margins. New retention is then cut in the portion of the filling already in, and the remainder of the filling built and correctly contoured.

Convenience Form.—No convenience form is necessary in this class of cavities, except for inlay fillings, which will be considered later.

Neglected Access Form.—In cases where large proximal cavities are of long standing and there has been much tipping to the proximal of one or both teeth, preliminary separation for good access is essential. Without this preliminary step, complete contour restoration and proper contact are impossible. This is particularly true when the cavity is in the mesial of the first molar. Many times the second bicuspid will seem to have been engulfed within the molar cavity. In cases where preliminary separations for obvious reasons are impossible, the evil may be partly overcome by the free cutting away of both buccal and lingual walls until the filling may be built in with a proximal surface slightly convex to the proximal. This is but a makeshift of a filling, however, and the resulting proximal space will always be defective.

Toilet of the Cavity.—In large decays, particularly if there has been a pulp canal operation, there is more or less danger in leaving coatings of various materials clinging to the walls. Care should be taken that the walls are scrupulously clean. It is an advantage if the cavity be scrubbed with solvents for the suspected coatings. The cavity should then be dried, the enamel walls planed, and the cavity freed of all debris.

Overdesiccation.—Particular care should be taken not to use excess desiccation in pulpless teeth as this will render them brittle and liable to fracture when put to use.

CHAPTER XIX

MANAGEMENT OF PROXIMAL CAVITIES IN INCISORS AND CUSPIDS NOT INVOLVING THE ANGLE (CLASS THREE)

Definition.—Class Three cavities are those in the proximal surface of incisors and cuspids where it is not necessary to restore the incisal angle. The angle may be allowed to remain when the enamel at the angle is supported by sound dentine to an extent which will give it sufficient resistance to prevent fracture under stress of mastication.

General Form of Class Three.—Cavities in incisor proximal surfaces differ from all others in that they are in the surface of teeth of a triangular form and the cavities, of necessity, must be of this form, rather than the typical box shape in the other classes of cavities.

Location of Primary Decay.—The location of primary decay, as with all contact decay, is gingivally from the contact point. This will result, as a rule, in the seat of initial decay being about midway from the incisal edge to the gingival outline. As the plates of enamel, both labial and lingual, are quite heavy and usually removed from direct stress, there will generally be considerable loss of dentine while the enamel walls are yet intact. The decay may be apparently small, yet reflected light by the use of a mouth mirror will show a discoloration of a well-defined area. The curved tine of an explorer may or may not enter from either the labial or lingual embrasure.

Opening the Cavity.—Bathe the surfaces of all the anterior teeth in that jaw with water to free them of microorganisms and gummy material, particularly the gingival border, and apply the mechanical separator.

Gaining Access.—With a small straight chisel of about one millimeter in width cut away the enamel edge, throwing the chips into the cavity. Adequate finger rest must be secured before applying the chisel and only small portions of enamel engaged at each application, as a failure in either respect may result in checking the enamel to a greater extent than desired. When sufficient entrance has been made to the cavity to admit the instrument, the remaining enamel margins may be planed from this direction until a ligature will pass from the incisal to the gingival line. Where time will permit, the case should be packed for preliminary separation as described in Chapter IX. If immediate separation and filling are to be practiced, the rubber dam should be adjusted and the mechanical separator placed and tightened to a snug pressure. The separator should be tightened from time to time until the required separation is obtained. The approximate space required is from one-half to one millimeter where only one cavity exists in the proximal surface, and a full millimeter in cases where two cavities exist.

Outline Form.—As these cavities are located in the most exposed portion of the mouth, esthetic reasons demand as little cutting as possible consistent with the demands for permanency. It is a good rule, however, in outlining cavities of Class Three, to extend in all directions until, when the filling is completed, the entire cavity outline not covered with gum tissue is in full view of the operator. (Fig. 37.) As stated before, excessive cutting to obtain this condition may be obviated by proper separation.

The gingival outline should be carried midway between contact and gum line, and farther extended to go under the gum when it approaches to within one millimeter of the gum. Great care should be exercised to square out both labial and lingual axiogingival angles, carrying them sufficiently into these embrasures for the cavity margins to be in full view as they pass under the gum.

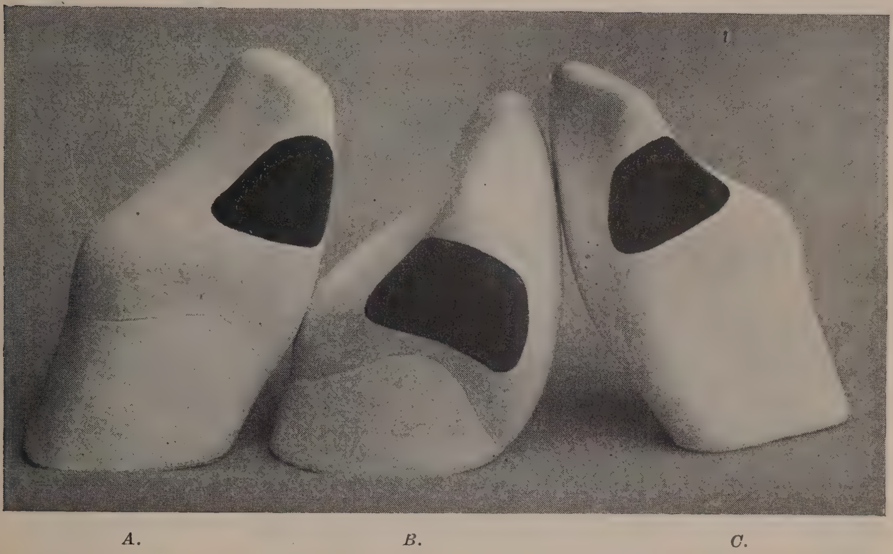


Fig. 37.—Class Three cavities filled so that the entire cavity outline, except that portion covered by gum tissue, is in full view of the operator. The gingival portion of *B* has been cut sufficiently low to be covered by gum tissue.

The incisal outline should be carried incisally until the margin of the filling is permanently in view, with a space sufficient to admit of the free use of the toothbrush on the margin. This would, in many instances, carry the margin beyond the incisal edge and make a Class Four cavity and is avoided only by separation and filling of the cavity to a slightly excess contour.

The labial outline should be carried into the labial embrasure until the margins are in full view. The enamel should be split away until full-length rods are obtained. On account of the exposed location of these cavities the esthetic reasons demand as little cutting labially as possible. As this margin is practically removed from the stress of occlusion, it is not essential that the enamel be supported by dentine in every instance. Care should be taken, however, that the rods are full length and that all rods are removed where there has been a backward decay as shown by a whitened powderlike condition at their dentinal ends.

Additional extension for esthetic reasons is sometimes required in the labial embrasure. This is more often true in the mesial cavities wherein the teeth are angular in form and present surfaces that are quite flat, resulting in a very square or prominent mesiolabial angle. In such cases the outline should be carried over the angle and into the labial surface, so that the metal may be brought into the light, otherwise the completed filling will have the appearance of a decay or dark spot on the tooth.

The lingual outline must be carried into the lingual embrasure sufficiently to be brought into full view in all cases.

In the case of teeth of rounded form, this will not always include the proximal marginal ridge. In teeth of a squared form and prominent lingual ridges, the marginal ridges should be included and the outline carried along the axial slope of the ridge. The fact that many cases show a lingual articulation and occlusion on the lingual marginal ridges of upper incisors will bring demands for including within the cavity the major portion of these ridges, unless supported by a good bulk of sound dentine. The failure to recognize this fact on the part of many operators is responsible for the loss of a large percentage of this class of fillings.

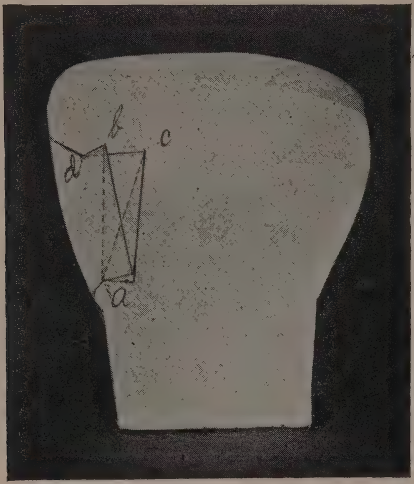


Fig. 38.—Drawing to illustrate the retention at the incisal angle of Class Three cavity, in shallow cavities with a short incisal line angle as *d—b,* the angle at *b* should be acute. In deeper cavities and longer incisal line angles as the one shown at *d—c,* the incisal point angle is efficient if it is a right angle and may even be obtuse. In the illustration shown, the filling would pivot to exit at *a.* Dotted lines *a—b* and *a—c* are the same length, hence the point angles of the two fillings would describe an are of the same circle in tipping to exit.

Resistance Form.—No special resistance form other than that just given is required in this class of cavities.

Retention Form.—When this order in the preparation has been reached, attention should be directed to the incisal angle, particularly in the larger cavities, as cases will be met in which it will be found necessary to remove the incisal angle to secure proper "retention form." This looking to the incisal first will decide this point early in the procedure.

The incisal line angle should meet the axial wall at least at a right angle. In cases where this line angle is short, as found in shallow cavities, the incisal line angle should meet the axial wall at a slightly acute angle. It is not necessary to make a convenience angle at the incisal point angle (Fig. 38.)

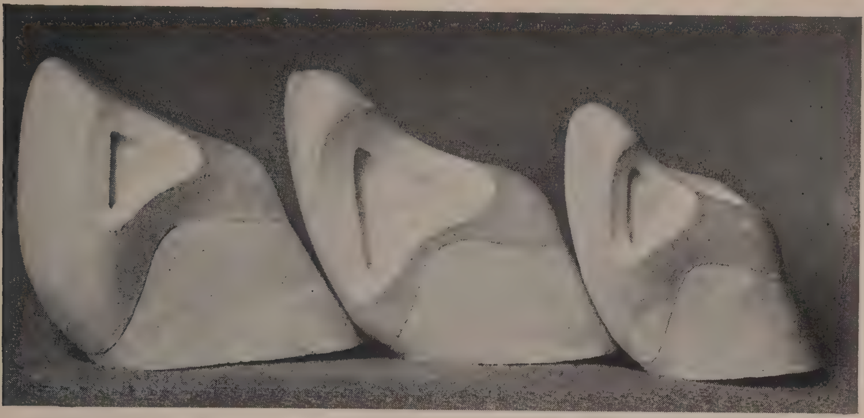


Fig. 39.—Class Three cavities prepared for cohesive gold. While the cavity in the cuspid, (*A*) restores the mesial angle, the shape of this cavity and the rules governing its management places it in Class Three.

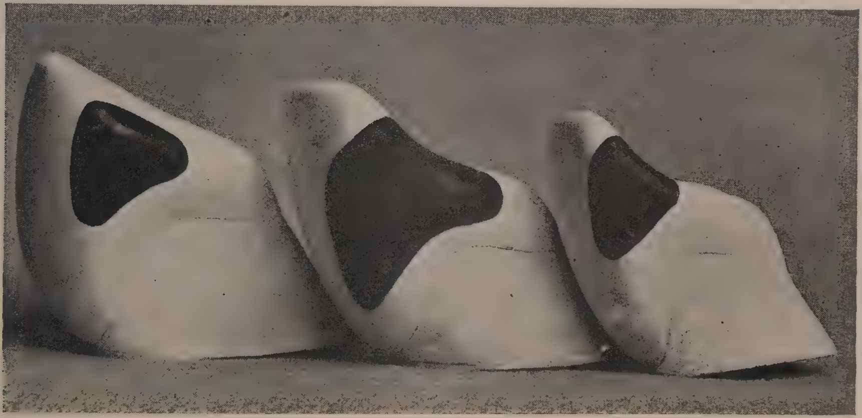


Fig. 40.—Class Three filled. Cavities shown in Fig. 39.

The bevel angle on the gingival wall becomes the fulcrum. It is only necessary that the distance from this point to the incisal point angle be greater than that from the same point on the gingival wall to the most external portion of the incisal line angle. The more shallow the cavity in Class Three, the more acute must be the incisal point angle.

Other Point Angles.—The gingivoaxiolabial and the gingivoaxiolingual point angles are now carried into the dentine at the expense of both axial and external walls, care being given not to groove the gingival wall.

Line Angles.—Line angles are made with small hatchets and hoes of suitable sizes, say, one-third to one-half millimeter in width, with keen edges and well-defined corners which have not been rounded through careless sharpening or wear.

The Axiolabial line angle is chased and sharpened for its entire length, making it particularly definite as it approaches each of the point angles.

The Axiolingual line angle is made definite for one millimeter in each direction from its two point angles, omitting the central portion, as this precaution will give added resistance form to the lingual wall. The sharpening of these line angles is best accomplished by engaging the instrument in the dentine the desired distance from the point angle and cutting to the angle.

The Gingivoaxial line angle should be well defined to make the gingival wall meet the axial at a definite angle, but should in no way be a ditch or groove.

The Gingivolabial and gingivolingual line angles should be moving away from their point angles and ending at the dentoenamel junction. As the general form of the cavity is that of a triangle, these angles will always be acute.

Gingival Wall.—The gingival wall should be flat in every direction.

Axial Wall.—The axial wall should be left as decay has left it in the central portion, and all additional cutting should tend to make it take on the form, in miniature, of the surface of the tooth in which the decay has originated. A disregard of this rule will endanger the pulp, whereas, if the axial wall is left as convex as possible, the pulp has all possible protection.

Labial and Lingual Walls.—These walls should be, as far as possible, of the same thickness for their entire length, which will result in their inner surfaces being of the same contour as the external surface of the tooth.

Convenience Form.—Two convenience points are advisable in this class of cavities, cut in the gingivoaxiolabial and the gingivoaxiolingual angles. The filling should be begun in the latter angle.

Removal of Remaining Decay.—At this point inspect the dentoenamel junction for softened dentine. Also, the entire axial wall should be scraped with large spoons for the removal of the last of the softened dentine, the cavity disinfected, dried, phenolized, and again dried. Pulp protector should be applied when indicated.

Finish of Enamel Walls.—The enamel walls should be planed to full cleavage, with suitable instruments of chisel edges, not forgetting the incisal and gingival inclination of the rods of these locations. Bevel the cavosurface angle, give the cavity its toilet, and immediately place the filling.

In Pulpless Cases.—When the axial wall has been lost by reason of pulp removal, the entire pulp chamber should be filled with cement of a very light yellow color or even white. In extremely frail teeth this may be only partially filled and the remaining portion used for retention.

CHAPTER XX

MANAGEMENT OF PROXIMAL CAVITIES IN INCISORS INVOLVING THE ANGLE (CLASS FOUR)

Definition.—Cavities of Class Four are those in which the incisal angle has either been lost or cannot be safely retained. The decision as to its restoration is of most vital importance. To cut the angle from nearly every incisor which has a proximal decay is little short of malpractice, while at the same time to attempt to save those not wholly and adequately supported by dentine is to invite many disastrous failures.

Conditions Demanding Frequent Angle Restoration.—First, when contact is in the incisal third. In such cases a very small decay will involve all of the dentine toward the incisal angle.

Second, incisors which have long flat proximal surfaces. Such teeth will show a line of decay extending gingivoincisally and may entirely weaken the incisal angle before the pulp is in danger.

Third, the pulp may be involved and its removal materially lessens the resistance of supporting dentine at the angle.

Fourth, the angle under consideration may be so located that it is frequently required to stand great stress in service. This is a point which must not be overlooked, as an angle which stands well exposed must bear much greater and more often repeated force than an angle which does not occlude or cannot be brought into articulation.

Difference Between Mesial and Distal Surfaces.—The above four conditions will be more frequently met with in mesial surfaces, hence the mesial angles are in greater danger and more often require restoration.

Plans of Angle Restoration.—There are four general plans of restoring the incisal angle which are worthy of consideration. Many plans have been advanced from time to time, but the four given below seem to have remained in favor.

Retention Form in Class Four Fillings.—With each of the plans presented and generally practiced, the effort is made to remove or nullify the principle of the lever.

With proximal fillings wherein the force of mastication is brought in direct contact with the filling, principles of the lever must be reckoned with. The force of mastication is the power, the filling the lever, the anchorage in the point angles the load and the point on which the filling would most likely pivot to exit the fulcrum. By a study of the case we find we must deal with the force of levers of both the first and second class.

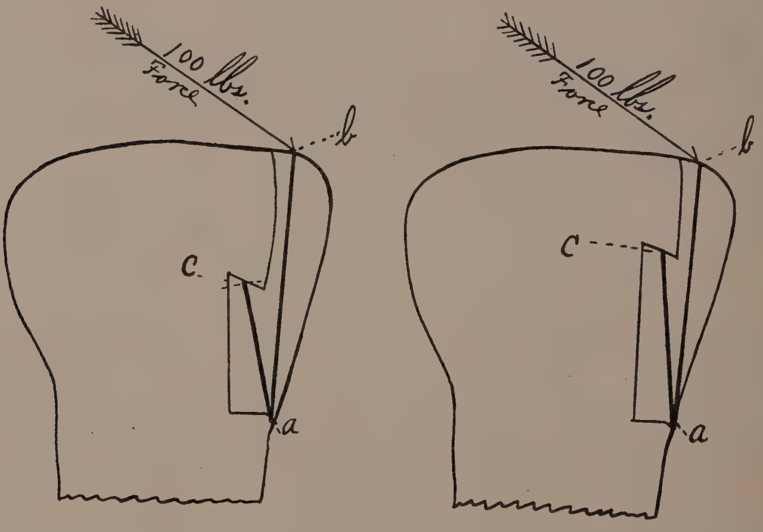
In Fig. 41 we have an illustration of a Class Four, plan one, filling wherein the principles of a lever of the second class are fully operative. The heavy long lines *a-b* represent the full length of the lever. The short heavy lines *a-c* represent that part of the lever which is the working arm, as the load is at *c*.

That we may study the amount of anchorage to be provided for at the incisal angle (*c*), we will ignore the assistance of the two gingival point angles, and for that reason they have not been shown in the drawing. We here have a lever of the second class with the fulcrum at *a*, the load at *c*, and the force at *b*.

In order that we may not inject into the problem at this time the principle of the bent lever, we will consider that by the lateral movement of the mandible the force is applied at right angles to the "lever-arm." In diagram *A*, Fig. 41, the working arm is one-half of the lever which is of the second class. We then have the following with x representing the load, or unknown quantity:

$$100 \text{ lbs.} : x :: 2 : 4 = \frac{400}{2x} = 200 \text{ lbs.} = x.$$

It would therefore follow that an incisal point angle placed midway between the gingival wall and the incisal surface of the filling would be required to stand a strain just double the force at the incisal, or place of impact.



A. B.

Fig. 41.—Drawings to illustrate the principle of the lever in the dislodgment of fillings of Class Four, plan one.

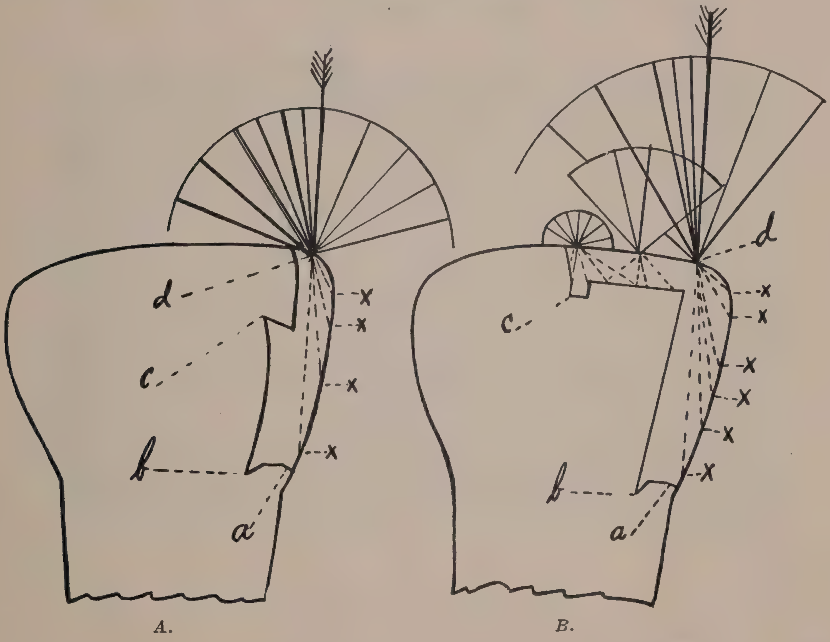
In diagram *B*, Fig 41, the incisal point angle is placed three-fourths of the way from the gingival to the incisal and we then have:

$$100 \text{ lbs.} : x :: 3 : 4 = \frac{400}{3x} = 133\tfrac{1}{3} \text{ lbs.} = x.$$

This shows a strain on the incisal point angle of 133 pounds. It will therefore be seen that the incisal point angle should be laid as close to the incisal edge of the tooth as the strength of the dentine protecting that angle will permit, as it follows that: *"The farther the incisal angle is from the force of mastication the greater will be the strain on both dentine and filling at this angle."*

With Fig. 42 we will consider the principles in a little more complicated form. Let *a* represent the fulcrum, *b* and *c* the loads, and *d* the point of the application of the force. The radii of the arcs of the circles represent a few of the directions from which force may be received by the filling. With the light lines, the force would be absorbed by the walls of the cavity. Force from the direction of the dark lines would put into operation the principles of the lever.

In diagram *A*, Fig. 42, the filling would operate as a lever of the second class upon the load at *c*, as described in Fig. 41. With the gingival point angles at *b*, the filling would operate as a lever of the first class over the same fulcrum (*a*), provided the gingival outline or fulcrum has been laid higher than the point angle and therefore nearer the point of the application of the force.



A. *B.*

Fig. 42.—Drawings to illustrate the principle of the lever in the dislodgment of fillings of Class Four, plans one and two.

In case the gingival margin has been laid lower than the point angle or farther from the point of impact than the fulcrum, we have a lever of the second class which when figured out will draw an immense load as shown in the explanation of Fig. 41.

In case the gingival point angles are cut more rootwise than the gingival margin and we have a lever of the first class, we must consider the principles of the bent lever. When the direction of the force (or of the resistance) is not at right angles to the arm or the lever on which it acts, the "lever-arm" is the length of the perpendicular from the fulcrum to the line of the direction of the force (or the resistance).

We must therefore conclude: First, that gingival point angles should be placed so as to extend more rootwise than the height of the gingival line at the proximal (that part of the gingival wall which is nearest the incisal is regarded as the highest point). Second, the farther the gingival wall with all its parts is from the incisal, the greater will be the length of the power arm with each individual blow. Third, the nearer the gingival wall is to the incisal, the less the number of directions from which force may be received which will act upon the filling as a lever.

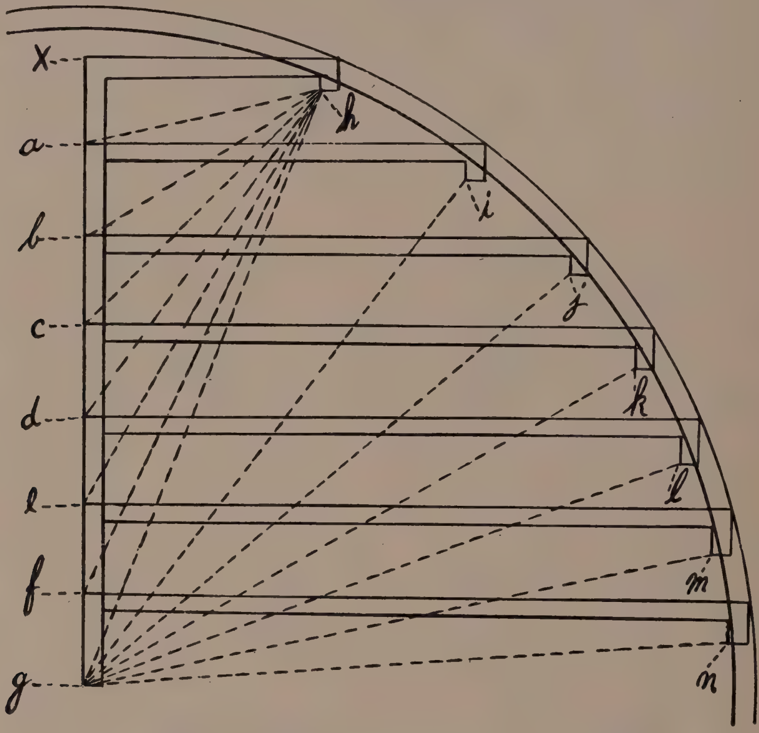


Fig. 43.—Drawing to illustrate the difference in the directions the point angle fillings take in tipping to exit with various fillings.

In order that we may eliminate the principles of the levers, the step cavity, in Classes Two and Four, has been devised as shown in diagram *B*, Fig. 42. It will be seen by the radii of the three arcs drawn that the increase of the surface of the filling exposed to force does not increase the dangers of the lever, as the area of the seat of the filling has also been increased, which will absorb the force beneath the increased surface. Again, so long as the incisal angle in the step (at *c*) holds and the filling material remains rigid, the lever principle has been eliminated as regards all other anchorage of the filling.

Direction of the Incisal Angle.—Fig. 43 is a drawing to illustrate the difference in the directions the point angles take in tipping to exit with various filling. Let the perpendicular shaft represent the varying length of Class Four fillings and the horizontal bars the varying lengths of the step in plan two of this class. The dotted lines are the radii of the various circles, the arcs of which the point angles would describe in moving to exit, pivoting on the gingival margin. The length of the step portion relative to the height of the filling determines the direction the incisal point angle must take to exit. With a short proximal portion and a comparatively long step portion, the first movement of the point angle is almost perpendicular. See fillings in Fig. 43 (*a, x, h;* also *g, f, n*).

Note the difference in the direction the point angle would take to exit with an increased length of filling incisogingivally. Also see *h, x, a,* and then *h, x, b,* and on down until it is *h, x, g.* It will be seen that there is a gradation toward the horizontal movement of the incisal point angle to exit. Again note the change of direction to exit of the incisal point angles in *g, a, i,* and then *g, b, j,* then *g, c, k,* and on down to *g, f, n.* We see in this series that there is a gradation toward the perpendicular movement of the incisal point angle to exit.

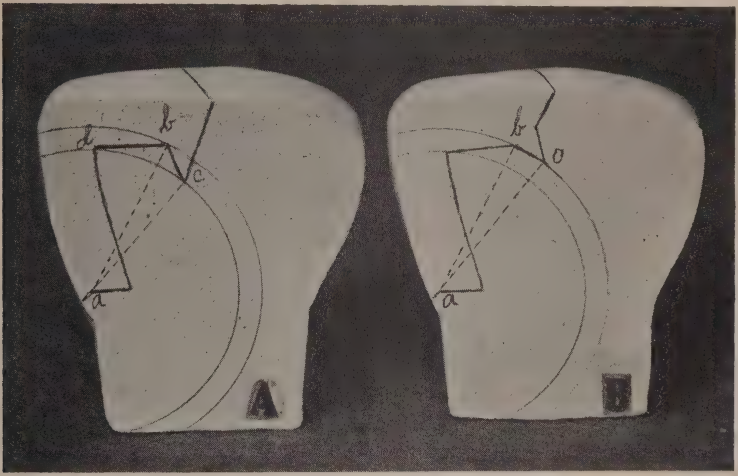


Fig. 44.—Drawings to illustrate the importance which should be given to the proper placing of the incisal point angle in fillings of Class Four, plan two, with particular reference to the plane in which wall *b*—*c* should be cut.

In the first instance we lengthened the axial wall, using the same length of step. In the second instance we shortened the axial wall and at the same time lengthened the step, and the change is more rapid. It would seem then that the direction to be given the incisal point angle is determined by the degree of the circle in which lies a line drawn from the deepest portion of the incisal point angle to the fulcrum. (See dotted lines Fig. 43.) The nearer this line in a given case approaches the perpendicular to the axial part of the filling, the more essential is it that the point angle be cut in the same plane as the axial wall. Also the nearer this line approaches 90 degrees from the perpendicular, the more essential is it that the incisal point angle be cut at 45 degrees to the perpendicular of the axial wall.

By a study of Fig. 44 it will be seen that the incisal angle of *A* would be effective, while *B* would offer no resistance to exit with a filling pivoting at *a.*

By materially shortening the axial walls of both, the point angle of *B* becomes effective and that of *A* ineffective.

As shown in the drawings in *A*, the dentine included in *b, c, d* is the retention produced by having dotted line *a, b* longer than line *a, c*. In *B* these lines are the same length, hence no retention. The filling becomes a lever to lift the gingival point angles.

The Gingival Angles.—In the study of the gingival angle retention, we will eliminate the incisal angle and consider that it has been improperly laid or has been weakened and the lever force has been transmitted to the gingival angles.

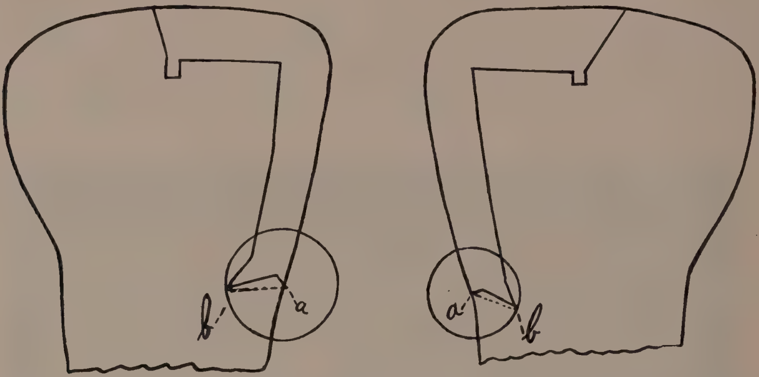


Fig. 45.—A study in the proper placing and depth of the gingival angles.

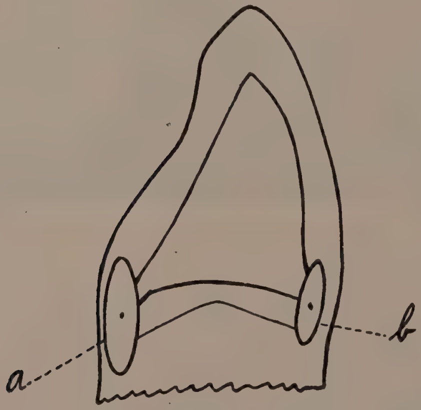


Fig. 46.—A study of the planes in which the gingival angles should be laid.

In Fig. 45, *a* is the fulcrum and *b* the extreme point of the angle. Dotted lines *a-b* are the radii of the circles the arcs of which the point angle fillings would describe in going to exit. The two gingival point angles should be of different depths so that they will describe the arcs of different circles in being drawn to exit. It is most convenient to make the gingivoaxiolingual the deeper.

It is also essential that the two gingival point angles be so laid that the circles, the arcs of which the point angle fillings describe in passing to exit, stand in different planes as illustrated in Fig. 46. Failure to observe the last two principles given removes retention form as regards the gingival angles.

First Plan of Angle Restoration (Class Four)

The first plan of anchorage is made by undercutting the incisal edge. This plan is indicated in teeth of rather thick incisal edge that are rather short and stocky, as they have a greater body of dentine near the angles upon which to depend.

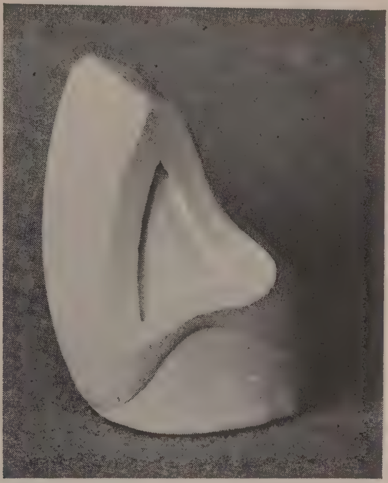


Fig. 47.—Cavity of Class Four, plan one, for cohesive gold.

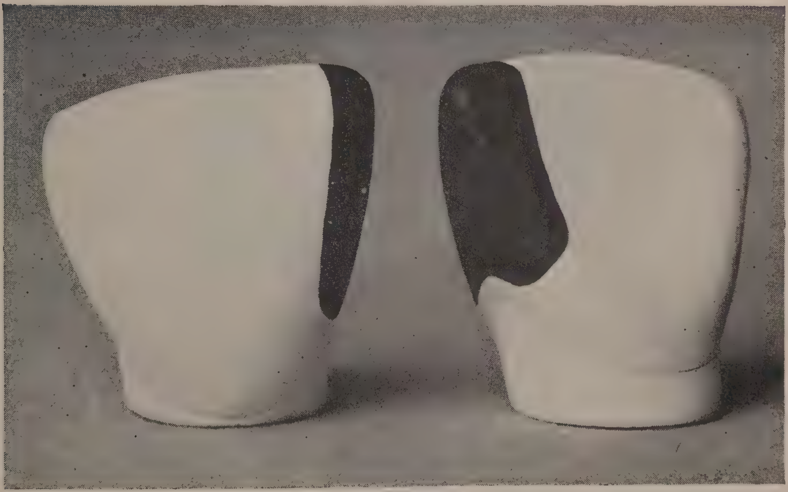


Fig. 48.—Class Four, plan one, cavity filled. Labial and lingual views. Cavity shown in Fig. 47.

As a rule the horns of the pulp in such teeth are well retracted, at least in adult mouths, and there is less danger of pulp exposure as compared with the teeth of thin edges and angular outline. If this plan has been decided upon, the cavity should be cut well to the gingival, particularly at the gingival angles, in some cases to the extent that the gingival wall is made convex to the incisal.

The gingival point angles should be deep and well defined at the expense of both gingival and axial walls. This is particularly true of the gingivolingual angles, to protect against the torsion strain.

To Assist the Incisal Angle.—To resist the tipping strain, both the labial and lingual walls should be slightly grooved along the axiolabial and axiolingual line angles much in the same way as with large Class Three cavities.

The labial outline should so proceed that the completed filling will be of about equal width for its entire length except that as it approaches the incisal edge it should be slightly curved to the axial.

A Rule for Labial Outlines.—All cavity outlines in incisal angle restorations should curve to the axial as they approach the incisal edge. The nearer this outline approaches the central axial line of the tooth, the greater should be the curve. When the central axial line is reached by a cavity outline, the same should then be extended to involve the opposite angle. There are exceptions to the above rule but maximum resistance to stress is only thereby obtained.

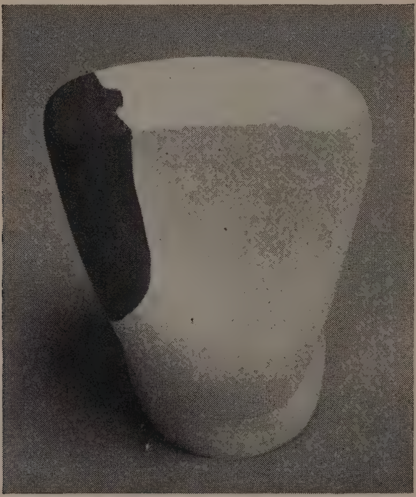


Fig. 49.—Shows incisal outline in Class Four, plan one, fillings, with direct occlusion.

The Necessity for Curving to the Axial.—When approaching the incisal edge, curve to the axial so that the last rods at the cavosurface angle may be adequately supported.

Arrangement of Enamel Rods at Incisal Edge.—In cases where there has been incisal wear, the enamel rods of both the labial and lingual plates stand on the dentine with their sides presented to the force of service.

They are therefore obliged to stand the force of the bite in a manner best illustrated by a cord of wood. Unless the ends of the pile are well supported or well sloped, they crumble away when the load is received. A large percentage of fillings where this precaution has been neglected fail, due to the breaking away of the enamel at this point.

The incisal outline as it crosses the incisal edge of thick teeth should have in its center a curve toward the axial caused by a slight groove in the center of the dentine. This groove, which ends at this point in the cavity outline, should originate at the external end of the incisal line angle. If there is sufficient dentine, and there generally will be in the class of cases calling for this plan of restoration, this groove is of best service if it be a flattened groove and made with a small hoe or hatchet. (Fig. 49.)

The lingual outline should be the same as for large Class Three cavities except in the incisal third when it should curve to the axial even more rapidly than the labial outline and for a longer distance, resulting in cutting away more enamel from the lingual than is removed by the labial outline. This is made necessary by the fact that all stress is from the lingual.

With lower incisors the reverse is true and it is necessary to remove slightly more of the labial enamel in angle restoration, a fact which materially mars these teeth from an esthetic point of view. Fortunately, we have comparatively few angles to restore on lower incisors, but when they are presented the fact must be borne in mind that they receive the major portion of stress from the incisolabial direction.

Second Plan of Angle Restoration (Class Four)

The second plan of restoration is indicated in teeth that are of medium thickness, particularly if they are of angular build or have a direct contact on the incisal edge either in occlusion or articulation, and consists in the addition to plan one of what is termed the incisal step. The cavity proper is prepared as outlined in plan one up to the forming of the step.

The incisal edge is cut away with a narrow-edged carborundum stone, the cutting being extended toward the opposite angle a distance equal to the width of the cavity proper. The incisal outline should avoid both the centers of primary calcification and the point of coalescence, two weak places in enamel construction. The cutting should be more at the expense of the lingual side of the tooth by one-half to one millimeter.

The depth of this step, incisogingivally, will depend upon the thickness of the cutting edge, and the probable stress it will receive. The thinner the edge and the greater the probable stress, the deeper must be the step. The majority of cases will show not to exceed one millimeter of gold on the labial in the step portion.

Technic of Cutting.—A small round bur is then used to cut a groove in this newly formed pulpal wall, near the dentoenamel junction next to the lingual plate of enamel. The lingual enamel is then removed with a chisel, thus carrying that portion of the pulpal wall to a lower level. This process is continued until it is at least one-half millimeter to one millimeter lower than the labial portion of the pulpal wall. This leaves the major portion of the dentine supporting the labial plate of enamel.

The point angle in the step portion should be deepened and made acute largely at the expense of the pulpal wall. This will place it in just the right position to resist stress from the probable source and prevent tipping. (See Fig. 50.)

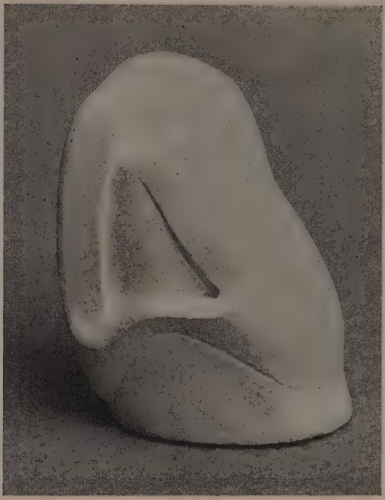


Fig. 50.—Cavity of Class Four, plan two, for cohesive gold.

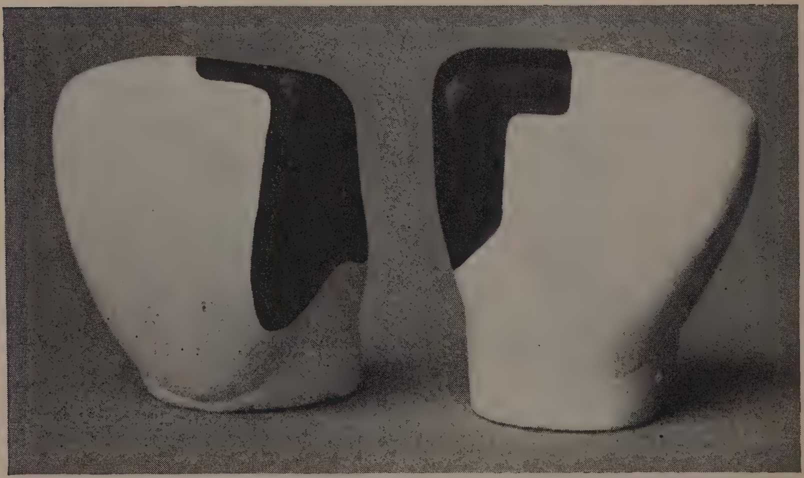


Fig. 51.—Class Four, plan two, filled. Labial and lingual views. A very popular method. Cavity shown in Fig. 50.

Third Plan of Angle Restoration (Class Four)

This plan is the addition to plan one of the lingual step. (See Figs. 52 and 53.) It is particularly indicated in cases of long incisors which are quite thin labiolingually and subjected to a long sweep of the lower incisors in the movements of articulation, or what is spoken of as the "scissors bite."

This plan is also indicated in cases where the axial wall extends out to the enamel edge on the lingual, thus removing the lingual wall.

The labial outline is the same as with the first plan of restoration. The step is formed on the lingual by cutting away the enamel from the lingual surface of the tooth toward the central axial line for a distance of from one to two millimeters at the incisal edge.

As the gingival is approached, the cutting is narrowed to a point where the marginal ridge may be crossed at right angles to meet the gingival portion of the outline. This will form a V-shaped axial wall of dentine facing the lingual. There should be cut a flat-floored groove in this dentine parallel with the remaining enamel wall, ending in the gingivoaxiolingual angle which should be an acute convenience angle. The plan gives great resistance to stress from lingual pressure.

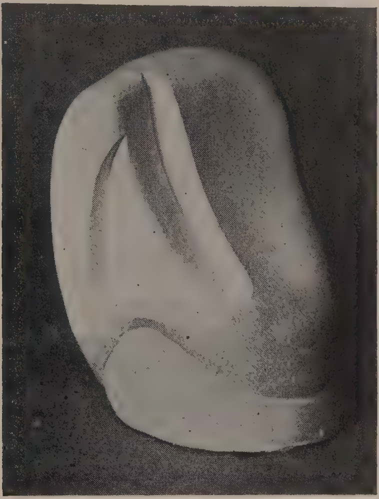


Fig. 52.—Cavity of Class Four, plan three, for cohesive gold.

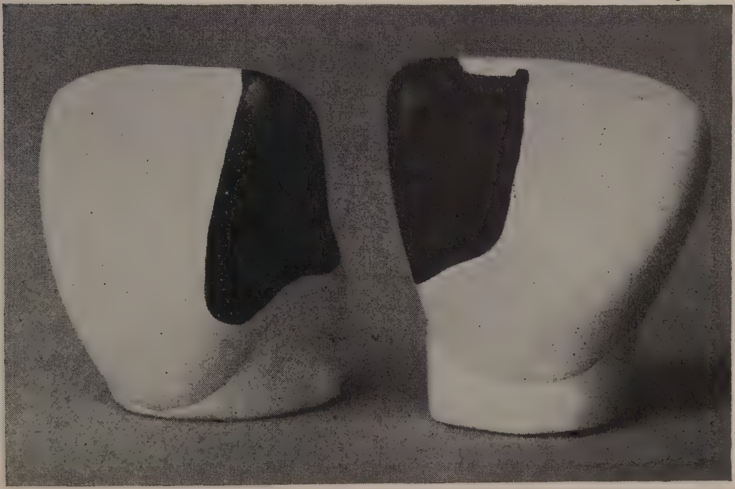


Fig. 53.—Class Four, plan three, filled. Labial and lingual views. Cavity shown in Fig. 52.

Fourth Plan of Angle Restoration (Class Four)

This plan consists of resorting to all of the features of resistance and retention embodied in plans two and three by combining both the lingual and incisal steps. Each of these has been fully described and the method of cutting both steps to the same should not prove hard to accomplish.

By this plan the maximum resistance and retention forms are secured with the minimum loss of dentine. It must be remembered that resistance to stress is good in proportion to the amount of securing dentine retained, hence it should be sparingly cut way. The removal of enamel to lay bare dentine wherein to lay anchorage is only harmful from the esthetic standpoint and is of little loss when taken away from a surface not in view, as is the case when we cut away a portion of the lingual plate.

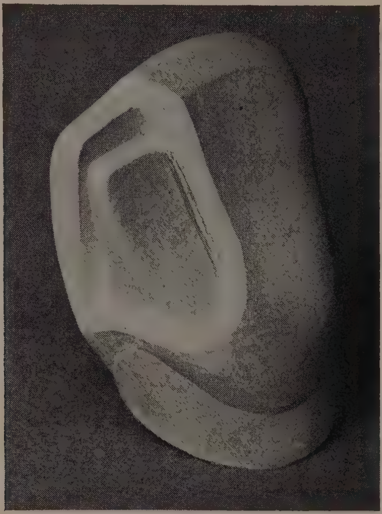


Fig. 54.—Cavity of Class Four, plan four, for cohesive gold, showing maximum anchorage with a minimum loss of dentine. The use of this plan is advised when the lingual stress is great.

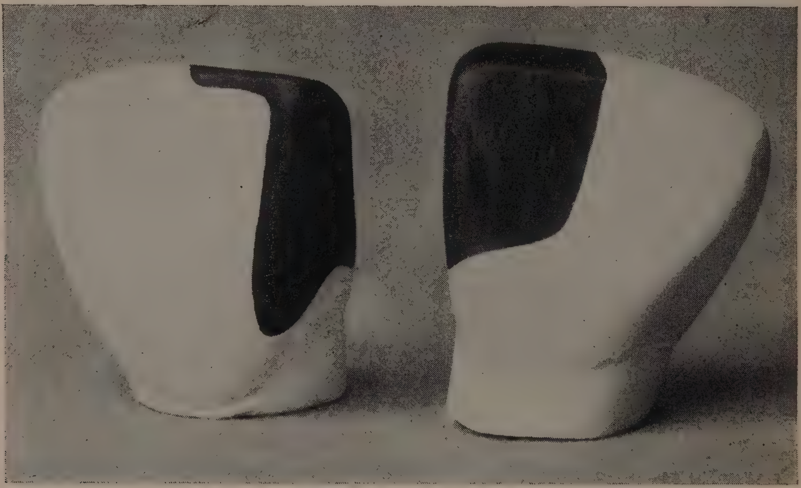


Fig. 55.—Class Four, plan four, filled. Labial and lingual views. Cavity shown in Fig. 54.

Cavities in the Distal of Superior Cuspids.—On account of the peculiar articulation of the lingual surface of superior cuspids this cavity has been left for separate consideration. The plan given is a modification of plan three, using a lingual step not unlike the occlusal step in a Class Two cavity.

Access is an easy matter as the decay is in the most prominent part of the distal surface, and a little work with the chisel gives access to the cavity.

Outline Form.—In outlining the cavity proper, most of what has been said about plan one should be followed here.

As to the lingual outline and that of the step, particular attention must be paid to so placing the margins as to remove them as much as possible from the stress of articulation.

The Step.—The lingual step is added to this cavity as it materially assists in retention, resistance, and convenience forms.

In the laying of the walls of the step portion, the particulars are carried out much as though the lingual surface of the cuspid were an occlusal surface, as next to an occlusal surface it receives the greatest stress in articulation.

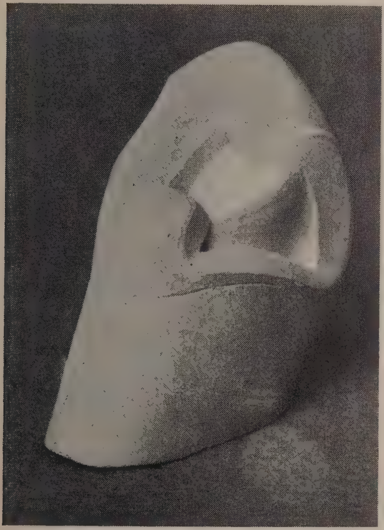


Fig. 56.

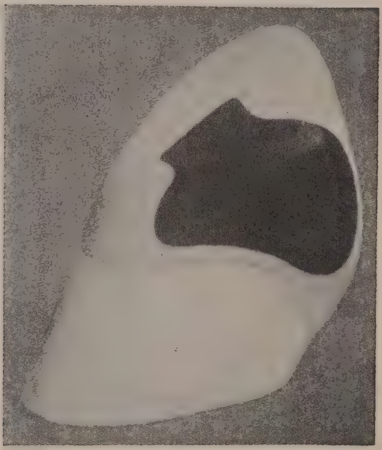


Fig. 57.

Fig. 56.—Cavity of Class Four, modified plan three, for cohesive gold in the distal of the superior cuspid. This plan is sometimes used to advantage in the incisors when the tooth is short and stocky. In such cases the lingual step is made to include the lingual pit.

Fig. 57.—Class Four, modified plan three, filled. Cavity shown in Fig. 56.

Axial Walls.—It will be seen that this cavity has two axial walls. The one in the cavity proper is the axial, while that in the step is termed the lingual axial wall.

The lingual axial wall should be placed on a plane parallel with the lingual surface of the tooth. Its surrounding line angles should be laid just below the dentoenamel junction.

Convenience form in this cavity is pretty well secured by the addition of this lingual step, as the filling is then easily built in from the lingual direction. Both gingival point angles in the cavity proper should be made convenience angles as well as the axiogingivomesial point angle in the step portion.

CHAPTER XXI

MANAGEMENT OF CAVITIES IN THE GINGIVAL THIRD (CLASS FIVE)

Gingival third cavities differ from all other cavities in the teeth in that they originate on perfectly smooth surfaces generally without flaw in enamel formation and without covering of any kind. To state it more concisely, there seems to be no predisposing cause.

Their prevention is an easy matter, as the accumulation of sordes, which is the sole exciting cause, is unprotected and of easy access to the brush, so that patients with this class of decay are paying the penalty for the careless neglect of the simplest forms of oral cleanliness. With these facts before us, it becomes the duty of every practitioner to fully advise the patients of the neglect of their mouths in this particular locality, in an effort to check further destruction.

The tendency to spread in the enamel is a characteristic of this class of cavities. They usually originate near the center of the buccal surface near the free margin of the gum and seldom stop until they have extended both mesially and distally nearly to the angles. The fact that the encroachment seldom reaches the angle in the external enamel decay is a point to be considered in the study of extension for prevention in this class of cavities. It appears that when the outline is carried quite to the angle, secondary caries rarely occurs.

The gingival outline should be laid below the gum line for its entire length until the angles are reached, when it should emerge from beneath the gum at a right angle to the free margin of the gum.

The occlusal or incisal outline should be carried to a region of sound enamel. Where this extension does not carry this outline farther than one millimeter from the free margin of the gum, further extension should be made. With teeth surrounded by a heavy gum, particularly if there seems to be a condition of hypertrophy present, the occlusal outline should be laid at least two millimeters from the border of the gum.

Retention Form.—Retention is secured by squaring out the four point angles. The axial wall should generally be left as decay has left it in the central portion. Any subsequent cutting should be of such a nature as would tend to make it convex to the external, or so to speak, the miniature of the tooth's surface in which it is being cut. An effort to cut a flat axial wall mesiodistally will often endanger the pulp and is unnecessary as these cavities need no resistance form.

In large buccal decay often the gum has so grown into and filled the cavity that the adjustment of the clamp and rubber dam is difficult or impossible.

In such cases if the pulp is not involved, much assistance is secured by packing the cavity full of guttapercha base plate, allowing it to crowd well down upon the gum. In a few days the gum will have receded or will have absorbed sufficiently to permit convenient access.

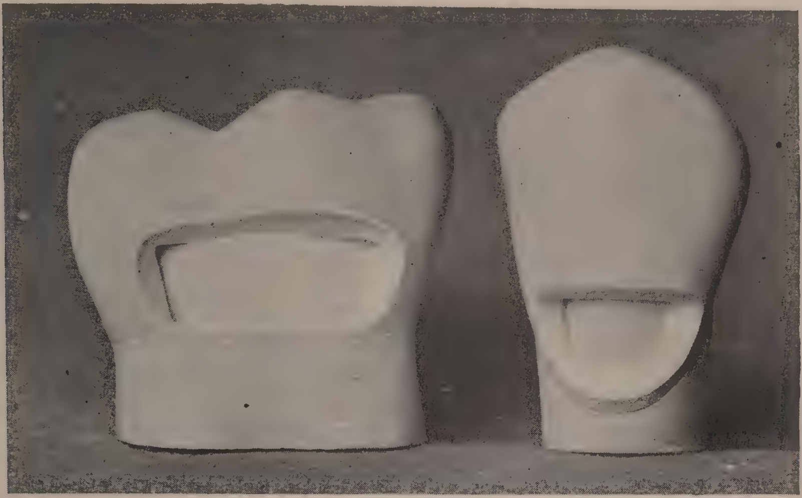


Fig. 58.—Cavities of Class Five for cohesive gold or amalgam.

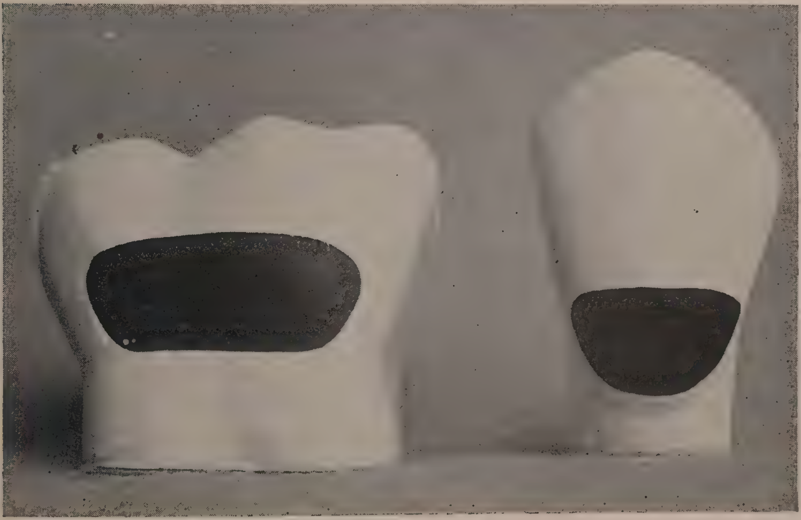


Fig. 59.—Class Five filled. Cavities shown in Fig. 58.

If the pulp or pulp canals are involved and require treatment, make an application of the indicated remedy, covering this with amalgam which should fill the cavity. Care should be taken that the gingival wall has been planed to a solid condition. During this operation, dryness may be obtained by the assistance of cotton rolls.

When the patient returns, the clamp will ride on the amalgam at the gingival margin, and access to the pulp canals may be had through the upper portion of the amalgam. After the pulp canals have been filled, the dam may be removed and the remainder of the amalgam excavated, and cavity preparations may be proceeded with, as well as the placing of an amalgam filling under dry conditions by the use of cotton rolls.

If gold is to be used, the gold inlay is clearly indicated as producing the best results with the least tax upon patient and operator.

With labial cavities in the gingival third, the Hatch clamp will expose nearly every case presented and render access not difficult for the introduction of a cohesive gold filling. In cases of extensive gum recession on labial exposures, the porcelain inlay is clearly indicated and is considered in the chapters on that subject.

CHAPTER XXII

MANAGEMENT OF ABRADED SURFACES. OCCLUSAL AND INCISAL (CLASS SIX)

Definition.—Class Six includes the group of cavities necessary for the repair of injuries to the teeth through the loss of a portion of their articulating surfaces as the result of wear. The condition is abnormal and the extent of the destruction of tooth substance is by no means in proportion to the amount of use to which the teeth have been subjected. It will be noticed in mouths with teeth of short cusps, however, particularly if the incisors occlude directly upon the incisal edge, that there is an abnormal amount of lateral motion in the act of articulation, and in such mouths we find the maximum loss of tooth substance at any given age.

Cause Not Wholly Clear.—That friction is the sole cause for this lesion cannot be demonstrated, as the surfaces thus affected do not show the exact impression of the opposing teeth, neither is this condition always delayed till advanced years. Cases showing the advanced stages of this trouble will be occasionally met with in the mouths of people in middle life.

At the same time locations will be found on the occlusal surfaces of teeth which at one time must have been in articulation but are so far lost and seemingly worn away that they could not be brought into occlusion.

It would seem from a study of a great number of cases that there must be some causes, predisposing and exciting, not yet understood. It is not improbable that the cause is a fault in tooth structure, not so much in the constituents of the tooth as in the lack of strength in their combination. This conclusion would seem plausible from the fact that teeth similarly situated and of the same chemical analysis are affected to a different degree by even slight friction. The bond of union does not seem to be so strong.

The object in filling or in making a cavity to fill is to check the loss of tooth substance permanently by entirely covering the affected surface with a substance that will resist the full force of mastication.

Occlusal Surfaces.—In occlusal surfaces, particularly molars showing the first stages of general erosion, early interference is advised. As soon as a cusp is lost, it should be restored and if possible built high with gold, preferably an alloy of gold, either platinized foil or a cast inlay of gold alloy.

This early restoration of cusps to their full height will tend to restrict the lateral motion of the mandible in mastication, which seems to be a factor in this dissolution.

Cavity Preparation.—These cavities should be prepared as Class One and should be retentive throughout.

If the major portion of the occlusal surface of a single molar is affected, the whole occlusal surface should be lowered about one millimeter and the same restored with a cast inlay, sometimes termed an onlay. This is advised from the fact that the occlusal side of the filling may better fit the surface of the occluding teeth. This may and probably will necessitate the amputation of the pulp of this individual tooth, when the pulp chamber should be utilized for anchorage.

If contact points have been reached by this cutting, a mesio-occlusodistal cavity is imperative.

When wear is general, opening the bite to the extent of about one millimeter is preferable to cutting away any more tooth substance than is necessary for firm foundation and a correct outline.

With incisal abrasion, if the wear is not excessive, the building on of the "shoe," or covering the entire incisal end of the tooth with platinized gold, is the best practice. The gold inlay, which is treated in the chapters on inlays, is also of service.

When there is excessive incisal wear, opening the bite to practically normal is indicated, using gold for the posterior teeth and the porcelain crown for the anterior.

The entire enamel edge on the occlusal and incisal surfaces must be covered with a protecting layer of metal, as with these teeth the bond of union seems to be very weak, particularly at the dentoenamel junction, and they will chip away if not wholly protected from the force of mastication.

CHAPTER XXIII

EXCLUSION OF MOISTURE

The exclusion of moisture from most operations upon the teeth is essential to the successful manipulation of most filling materials, the sterilization of tooth structures and the prevention of infection, the cleanliness of cavity walls and margins. It is essential, also, in order to obtain a perfect view of the cavity, to observe the extent of decalcification, to diminish the pain of operations on living dentine, and to protect the soft tissues from injury in the use of caustic drugs, as well as to save the time of both patient and operator.

The methods of securing dryness during operations are:

The rubber dam, invented and given to the dental profession in 1864 by Dr. Sanford C. Barnum of New York.

Absorbents, such as napkins, cotton rolls and pads, packed about the teeth and near the mouths of ducts, assisted by specially constructed clamps upon the teeth.

The saliva ejector, by which the mouth is continually drained of secretions.

Objections to the use of the rubber dam are entirely on the part of the patient and can generally be traced to awkward and unskilled handling on the part of the operator. Every operator should become dexterous with each method, that he may employ the one most expedient in every case, using the one least objectionable to the patient.

To neglect dryness in dental operations is to invite disaster in root canal treatment as well as shortness of life to all fillings so placed. The operator who makes it a practice to neglect this essential obtains only a partial success in what he attempts.

So important is dryness that a patient should be warned that an operation where moisture has been allowed to flood the field is short-lived at best, and is liable to failure from that cause. Such conditions seldom arise, but they are occasionally met with due to location and extent of decay and the fact that there are some patients who are nauseated by the presence of the dam or absorbents around all but the most anterior teeth.

All filling materials are better manipulated under dry conditions at some stage of the operation, porcelain being the only one demanding moist conditions at any stage. This moisture in porcelain filling is only required to preserve the shade of the tooth substance to be imitated in the fused filling.

Materials to which dryness is most essential are silicate, cohesive gold, cement, and amalgam, named in the order of the importance of the demands. It is not true that these may be successfully manipulated under moist conditions. The effort is greater and the certainty of success is materially decreased.

The exclusion of moisture for sterilization and the prevention of infection is imperative in the last stages of cavity preparation, as it is physically impossible to perform the toilet and sterilization of the cavity properly when it is flooded, or even under moist conditions.

The proper treatment of pulp canals cannot be accomplished when flooded by the oral fluids, to say nothing of the introduction of a permanent root filling. The saliva is at all times impregnated with various forms of bacteria. Its presence invites failure by preventing sterilization of canals already septic and by permitting the reinfection of those already sterile.

Cavity walls and particularly the beveled margins must be freshly cut and planed after being moistened, before the introduction of a filling, as this is the only means of having an absolutely clean surface. We may resort to absorbing and evaporating the moisture from the walls and margins of a cavity, but there will invariably be left a residue or film upon the surface which is soluble in the oral fluids. No amount of pressure in introducing the filling, be it rubber, amalgam, or cohesive gold, will displace the moisture absorbed by the cavity surfaces, hence we have this layer of moisture or sediment intervening the filling and cavity. This will be exchanged in course of time for that upon the outside carrying with it bacteria and the products of fermentation or lactic acid, and secondary caries is the result. A molecule of water is so small that we have no conception of its size and no means of measuring it. Bacteria, which are the active agents of caries, will go where moisture will not, and the lactic acid which they secrete will go where the space is too small for the bacteria. It will be readily seen, therefore, that a moist surface or one coated with a residue of an evaporated mixture, whether medicine or saliva, intervening between a filling and a cavity wall, becomes a large passageway for the greatest enemy to tooth substance—lactic acid.

A better view of the cavity is obtained when dry, as its outlines become more distinct and its size and shape better defined. No mechanic ever thinks of trying to accomplish his best work with the object submerged in moisture. The rays of light are broken, objects are distorted and distances misjudged. The dentist who does not effectually exclude the moisture from the immediate neighborhood of a cavity will catch only a glimpse now and then of portions of a cavity, this being particularly true of the gingival wall, except in cases of gum recession.

The extent of decalcification of both dentine and enamel is diagnosed only when dryness is obtained to bring out the colors and shades of each, incident to these conditions. It is impossible to make proper cavity extension until the cavity has been made dry and so maintained for some time, as this is often the only means of detecting superficial caries. Semidecalcified tooth substance, when moist, materially resembles the healthy structures and must be dried for its injured condition to be detected.

The pain of cavity excavation is materially decreased by the extraction of the moisture from the dentine. The protoplasm within the dental tubules is the means of transmitting the sensation of pain to the vital pulp. Water is a large constituent of protoplasm and the extraction of this moisture through extreme and continued dryness removes the media of sensitiveness. It is therefore but human that the cutting of dentine is done with the moisture excluded.

When using caustic and concentrated drugs the moisture should be excluded that the drugs may not be carried away to the injury of adjacent tissues nor diluted to detract from their efficiency in accomplishing their purpose. Drugs placed in the cavities of teeth with moist margins, even when placed under fillings of rubber, cement, or amalgam, will follow the moisture of these margins to join that without, and great damage to the surrounding tissues often results from no other cause than a lack of the exclusion of moisture during the operation.

As a timesaver the exclusion of moisture should not be overlooked. With a dry cavity, the continued uninterrupted view permits more continuous work by the dentist. He does not have to wait for the patient to expectorate, make a few remarks, and leisurely resume a position in the chair, oftentimes not the position desired by the dentist. The operator will also be saved the necessity of drying the cavity after each flooding. All this takes valuable time—much more than is required to adjust a dam.

The rubber dam is the most dependable means of securing a dry field for operating, and its proper and speedy adjustment should be mastered. It is made in three thicknesses: heavy, light, and medium, the medium being the weight best adapted for all purposes when only one weight is to be kept at hand.

The size and shape is of little importance so long as it completely covers the mouth after it has been made to isolate the teeth desired, and also covers the chin and extends to either side of the mouth sufficiently for the proper engagement of the holder. This will require a piece from 5 to 6 inches square for all teeth back of the six anterior teeth, and is most frequently the size used on the anterior teeth. Some economy of rubber dam may be practiced, however, by cutting these squares in two triangular pieces, each of which will do for a separate case. These are applied with the diagonal of the quadrilateral (the hypotenuse) uppermost.

The holes to receive the teeth should be of the proper size and smoothly cut, otherwise there is an increased likelihood of the dam being torn in adjustment. This is best done by the use of the rubber dam punch, to be had at dental depots. In the absence of this, however, a very good result is obtained by drawing the rubber tightly over the tapering round handle of an instrument and touching the sharp edge of a knife to the rubber down the side of the handle, when a perfectly round piece will be cut out.

The distance between the holes will vary according to the space between the teeth, the height of the festoon of the gum, the weight of the dam, and the size of the teeth to be engaged. Generally speaking, the holes are cut from two to four millimeters apart in medium dam. The lighter the dam, the farther apart should be the holes. The holes are farther spaced with extremely large gum festoons, also when there is a considerable gum recession. If the holes are too close together under the above conditions, the dam may not cover the entire proximal tissues and a leakage may occur, or the gum septa may be unduly compressed and permanent injury result from strangulation. If the holes are too far apart, the rubber will wrinkle and bag at the proximal spaces and seriously hinder operations in these localities.

The location of the holes in the piece of rubber dam depends upon the location of the tooth to be operated upon and the teeth to be isolated. A beginner will do well first to place the dam over the mouth in the position desired for the outside edges, request the patient to open the mouth, and with the finger cause the dam to come in contact with the occlusal surfaces of the teeth it is intended to include, and then punch the holes as this trial indicates. By this method the operator will soon become familiar with the location in each case.

The number of teeth isolated depends upon the location and the operation to be performed. For short treatment cases, sometimes the placing of one or two teeth under the dam will suffice, but in most cases where fillings are to be made and polished, from five to eight teeth should be included so that a good view of the field of operation may be had and the loose folds of dam be carried farther away to avoid catching in the revolving points of the engine.

With anterior teeth the first bicuspid tooth of either side should be included, as the cuspid from its conical shape is often unsafe for a final ligature.

With bicuspids and molars as the objective teeth in an operation, the teeth anterior to the median line should also be included.

The clamp should be placed on the tooth back of the one to be operated upon except in mesial cavities in second molars, when the clamp may be placed on the second molar, thereby avoiding the clamping of the third molar except when absolutely necessary, as with distal cavities in second molars.

The placing of the dam requires the freedom of both hands of the operator, and the aid of an assistant is of value. The necks of the teeth upon which the rubber dam is to be placed should be cleansed of all calculus and sordes and flooded with a jet of water from the syringe. If the gums show hypersensitiveness they should be bathed with a solution of novocain, restricting its use to the gingival borders. Waxed silk should be passed through the proximal spaces to clean them and provide access for the rubber. If sharp margins of cavities cut the silk, these should be dulled by passing a thin ribbon saw through the proximal space, or, with the chisel, the margin should be carried sufficiently into the embrasure to give access.

When the teeth are in close contact so that the silk thread is passed with difficulty, the rubber can be made to pass more readily by the use of soap. This is done by placing the row of holes on the ball of the index finger, occlusal side up, and rubbing the soaped fingers of the other hand across the holes.

The occlusal side of the rubber dam is that which is in sight when the dam is in position.

The gingival side is the opposite side and is next to the gingival margins when the dam has been applied to the teeth.

The method of applying the dam is affected by whether a clamp is used or not, and the kind of clamp when one is used.

With the anterior teeth we do not generally use a clamp, and the rubber is placed by beginning at one side and then crowding the rubber through each proximal space in order until the opposite side is reached. The rubber dam holder should be applied to one side before commencing the adjustment, and as soon as the teeth have been forced through the holes, the other side of the holder should be attached.

With posterior teeth the holder should be attached to the short side of the rubber to prevent curling into the mouth. This would be the same side of the dam that the teeth are situated on in the mouth. The clamp to be used is adjusted as the first tooth receives attention, while the remaining teeth are pushed through one by one until the most anterior one is reached, when the other side of the rubber is secured with the holder.

To prevent leakage around the teeth the edges of the holes must turn toward the roots. This is accomplished by first pressing the dam well against the gums while grasping the rubber on either side of the tooth, and drawing it tight, then releasing the rubber so that it slackens, and gently moving it occlusally. This will generally have the effect of inverting the edges. If inversion is not complete, pass a small blunt instrument, such as a spatula or dull explorer, around the gingival margin to turn the edge under.

The use of the ligature is to assist in inverting the edges of the holes in the rubber dam and to secure the edges about the teeth in this position against displacement by the movements on the part of the patient or the operator.

Caution in the use of ligatures is most important as much permanent injury is done the gingival attachments by the careless crowding of these on the dental ligaments. This is particularly the case where the proximal gum festoons are high, because, in these cases, especially with young people, the attachment to the tooth is also high. A tight ligature tends to encircle the tooth in a straight line, and would thereby ride down the high proximal attachments if the ligature is crowded to the full height both labially and lingually. Hence, neither the labial nor the lingual should be crowded to the full height of the crown.

Ligatures are made of well-waxed floss specially prepared for the purpose, cut into lengths of about 5 or 6 inches. Some economy may be practiced where three teeth are to receive ligatures by starting with a piece about 12 inches long. Tie the first tooth in the center of the strand; when the ends are cut off, enough remains for the other two, thus getting three out of the amount usually used for two.

The cutting of the loose ends may be practiced for all the teeth except the lower anterior, cutting two or three millimeters from the knot. With the lower anterior teeth, ends of 2 or 3 inches should be left from each knot, and the farther ends of all tied together and weighted to overcome the efforts of the patient to elevate the lower lip, which endangers the security of the dam.

The most popular knot for tying ligatures is the ''surgeon's knot,'' either full or half. This knot is made by passing the ends around each other twice before each tie is made for the ''full surgeon's knot,'' while for the ''half surgeon's knot'' this is done with only the first half of the knot.

The ''Wedelstaedt tie'' is even more secure than the above and is made by using the first half of a surgeon's knot on the lingual side of the tooth first and then passing contacts with the ends on either side of the tooth, completing the operation with a half surgeon's knot on the labial, thus circling the tooth with two strands. Finish by varnishing the ligatures.

The removal of ligatures from the tooth when the operation has been completed should be accomplished before the rubber dam has been disturbed, and is best done by the use of a small sharp pointed knife, such as a No. 1 gum lancet. The thread is severed to one side of the knot on the labial or buccal side, and, by grasping the knot with a pair of pliers, the thread is pulled through from that side.

Where amalgam fillings have just been completed in a proximal space, the ligature about a tooth so filled as well as that around the proximate tooth should be cut so that the part lying gingivally from the fresh amalgam will be loosened and will pass out to the lingual embrasure. The ligature about a tooth in which there has just been completed a filling in both the mesial and distal portions should be cut on the lingual portion. This action will result in both ends being loose ends. Attention to this point will prevent the ligature from plowing a ditch in the amalgam and destroying the filling, in many cases, at the gingival cavosurface angle.

A good rule to remember is: with mesial fillings cut to the mesial of the knot; with distal fillings cut to the distal of the knot; where a tooth has both mesial and distal fillings, cut the ligature on the lingual side.

The selection of the clamp should be made, and then the clamp should be tried on the tooth it is to be used upon. A clamp should be secured which has jaws that fit the contour of the tooth at its gingival border, so that it will remain in position and yet not hug the tooth so tighly as to cause the patient pain or in any way injure the soft tissues.

The method of applying the clamp with the dam is to stretch the rubber over the clamp, then apply the clamp forces, and carry all to position on the desired tooth, using the hole in the dam as a means of getting a view of the tooth to be clamped, which aids in the placing.

Some of the older makes of clamps require that they first be placed in position on the tooth. Then, with the first fingers of each hand, distend the hole in the rubber dam sufficiently to slip it over the bow of the clamp.

In using cervical clamps for cavities on the buccal and labial surfaces in the gingival third, first the dam is passed to position and then the clamp is applied.

The removal of the rubber dam is accomplished by the following procedure:

First, remove the ligatures as before described.

Second, pull the rubber to the buccal or labial side, and with a sharp pair of scissors cut the strips passing between the teeth.

Third, disengage one side of the dam holder.

Fourth, with the right hand remove the clamp which should be holding the rubber dam, and remove all from the mouth immediately as the patient does not take kindly to any delays at this stage of the procedure.

Fifth, inspect the rubber to see if it has all been removed.

Sixth, inspect the teeth for any portions of rubber dam, ligatures, or stray particles of filling material. Now proceed to knead the gums with the fingers, at the same time flooding them with a forceful stream of water from the syringe, to cleanse them and to re-establish circulation.

The use of absorbents may be resorted to in place of the rubber dam for short operations, and more particularly with the upper teeth as these are the most easily managed. Absorbents are on the market at small cost in the form of rolls and napkins, and are to be discarded after once used, which is the only hygienic method. In their use, particular attention must be paid to the mouths of the ducts responsible for the most abundant secretions, the absorbents being so placed as not only to absorb readily the fluid which is ejected, but also to compress the ducts, thereby restricting the output.

CHAPTER XXIV

MANIPULATION OF COHESIVE GOLD IN THE MAKING OF A FILLING

Physical Properties.—The physical properties most desired in a filling are found in cohesive gold to a greater degree than in any other filling material. This places it at the head of the list as a means of restoring lost contour and preventing recurrence of decay. It is not affected by the fluids of the mouth; it may be very perfectly adapted to the walls of the cavity; the shrinkage and expansion range in varying temperature is very slight; the cavity can be filled immediately upon freshly cut surfaces before they have been contaminated, an advantage over the fused inlay; and when sufficiently condensed it possesses a greater specific gravity, hence density, than a fused inlay of pure gold. Hammered gold will flow under sufficient stress and always in proportion to the load, when it ceases to flow, unless the load is increased—a marked distinction between it and amalgam. This quality of gold makes it possible to build a filling which will at once sustain the force of mastication provided it has received sufficient aggregate weight during the process of introduction. This physical property of gold is also of service in that it does not further compress when firmly wedged between the walls of living dentine. These walls are elastic and retain a certain amount of residual elasticity which permanently grasps the unyielding gold. The expansion and contraction of gold under the varying oral temperatures are fully compensated for by this residual elasticity of the dentine so that the closely adapted cohesive gold filling is at all times in perfect adaptation.

The Objectionable Qualities of Gold.—Gold is a good conductor of thermal changes, hence it endangers the health of vital pulps. The color is an objection in anterior positions, and the process of building a filling is comparatively slow and taxing on patient and operator.

Welding of Gold.—Gold welds cold when properly prepared, is absolutely pure, and the contacting surfaces are clean. Any alloy in its substance (excepting platinum) or foreign substance upon its surface totally destroys this quality, until such substances are removed, when the property of welding cold again returns.

If the surface of the foil becomes contaminated with a nonvolatile substance, the injury is permanent.

To Protect the Surface of Gold.—Place a small pledget of cotton or spunk saturated with ammonia in the drawer where the gold is kept. Ammonium salts will form on the surface of the gold, which are easily volatilized by heat, leaving the gold clean. Before annealing, such gold will be found thoroughly noncohesive. This method of treating the gold to the fumes of ammonia will obviate the necessity of keeping more than one kind of gold on hand, as all will be noncohesive till annealed and can be used in either form.

Annealing gold is for the sole purpose of cleaning the surface of the gold by volatilizing any film that may have collected.

The degree of heat is about 1100° F., or just below red heat. In the daylight this color is not apparent, but on a dark day the dull red color should show. The gold is not materially injured if carried to the full red of 1200 or 1300 degrees, but in no case should the melting point be reached, as it destroys the possibility of adaptation to the walls of the cavity or to the surface of the gold already in place.

Methods of Annealing.—The electric annealer is by far the most satisfactory means, as it is always possible to obtain the same degree of heat for a continued period.

The next best means is to place the gold on a tray above a flame, thus separating the flame from the gold, preventing contamination of the gold with carbon and various gases which are frequently met with in combustion.

Gold should not be annealed by passing it through the open flame of either gas or alcohol, holding the gold either on a plugger point or the foil carriers. This is quite a common practice, which should be discontinued. In the first place, heating the gold with the open flame frequently contaminates its surface, to the injury of its welding properties.

Also, that portion of the gold next to the carrier is not sufficiently heated and remains noncohesive, a fact which is shown by the subsequent pitting of the surface of the filling during service by the flecking off of these noncohesive particles.

Specific Gravity.—The specific gravity of the cast gold inlay is about 18, varying a fraction of a point.

It is possible to condense a cohesive gold filling when confined between the walls of elastic dentine so as to obtain a slightly greater specific gravity than the cast inlay. This degree of solidity, however, is not possible of attainment unless the gold is confined and the wedging principle is taken advantage of.

Cohesion of Gold.—The surfaces of pure gold cohere readily when absolutely clean. This cohesion is brought about by the friction of the surfaces of the gold when in absolute adaptation. The degree of cohesion is in proportion to the friction. The friction is in proportion to the load, the extent of the surfaces in opposition, and the speed of the travel of the surfaces one upon the other. Hence, the greater the load, the smaller the surface, and the more rapid the movement of one surface upon the other, the greater the cohesion. Polished surfaces of gold must be brought into coadaptation in order to get cohesion. The smaller the surfaces and the thinner the sheets, the less the load and speed that will be required.

The serrated plugger points are used in condensing cohesive gold for the following reasons: that these polished surfaces may be kept small and uniform; that great pressure (load) may be easily exerted on the polished planes previously left in the surface of the gold by the wedge-shaped serrations. The mallet is applied to give the additional factor in friction (speed) as the fresh gold is moved over these small polished surfaces. The above conditions are obtained with the least exertion on the part of the operator and the least annoyance to the patient by the serrated plugger point, which is made of a collection of pyramids which act as so many wedges and exert great lateral force (load) upon the polished sides of their previous impression. That gold coheres to polished surfaces can be easily demonstrated by taking any cohesive gold filling and burnishing its surface to a glossy finish. Pellets of gold from the annealer will readily cohere and the filling may be continued to full contour by drawing a steel burnisher with heavy pressure over the surface of the fresh gold. This process proves that burnished gold coheres, but it is slow and laborious and objectionable to the patient; hence the reason for the serrated plugger point, which accomplishes the same result, the friction of polished surfaces of gold under pressure causing their welding.

Bridging is the term applied to that faulty manipulation which results in air spaces within the body of the filling, caused by the gold failing to reach the bottom of the indentations of the serrated plugger point.

The cause may be insufficient pressure being given the plugger point, the gold thereby stopping short of the bottom of the serrations, or it may be too much light malleting, going over the gold surface repeatedly, thereby bending down the crests of the pyramids and thus choking them to the entrance of the gold. Again, the cause may be changing to a plugger with a smaller number of serrations to the millimeter, or one wherein the serrations are not as deeply cut, resulting in a collection of pyramids that do not reach the bottom of the indentations made by the previous plugger.

Plugger Points Should Have the Same-Sized Serrations.—Each operator should have a set of gold plugger points of the same denomination as to the cuttings on the working point, to use in the same filling. When forced to change to one of different-sized serrations, the surface of the filling should be gone over entirely with the new plugger to be used, before adding additional gold. This will create a new set of facets to accommodate the gold added with the new instrument. A little care in this respect will greatly increase the specific gravity of the cohesive gold filling.

Rotating the Plugger in the Fingers Should Be Avoided.—The serrations are cut on the square, and unless the point is rotated one-fourth of a circle each time, the pyramids will ride the crests of the indentations; whereas, if the shaft is held in one position as described, the leverage produced by the plane on the surface of the plugged point coming in contact with the plane on the surface of the filling will twist the plugger point to position with each blow of the mallet. All this will prove plain to the vision if the field of operation is viewed under a high-power lens while operating with a serrated plugger on the surface of gold in a technic block.

The Size of the Plugger Point.—This depends entirely upon the force with which it can be used. It would seem from all the facts at hand that a point with the surface of one square millimeter should be regarded as the maximum. The force required to condense gold properly with a point of greater surface is either not permissible in many cases or often not possible with the operator.

A point of one square millimeter should receive a load of 15 pounds pressure at each contacting of the point.

At the same time, points of much less than one-half millimeter will chop the surface by disturbing the gold close to the point with each impact; hence we are limited to a narrow range as to size of points.

Preparation of the Foil.—The gold foil may be used from the book as it comes from the dealer and shaped as desired by the operator, or it may be purchased as cylinders, squares, ropes, and various other forms.

The shaping should be done without bringing the gold in direct contact with the fingers, and all manipulation and cutting should be done previous to annealing.

The Application of the Foil.—In whichever form the foil has been shaped, it should be so placed upon the surface of condensed gold that the leaves lie flat. If the pellets are placed so that the leaves of gold are crumpled in packing into place, the specific gravity will not be as great in the finished filling, nor will the cohesion be as perfect.

Sheet gold has a certain amount of spring left in it even after annealing, which has to be overcome if folded. The less handling of the sheets in folds when packing, the better the result. The gold should be grasped by the carriers with as small a bite as possible, to prevent precondensation, carried to the position desired, and condensed, with no attempt to shift its position by pushing or poking it around over the surface.

If the pellet is placed near a wall, it should be placed so that it lies fully against that wall in order that it may be crowded for room when condensed. Anything short of this will hinder the wedging principle in packing. If the new pellet is to come out to contour, it should reach slightly beyond contour and be burnished back to contour with a flat-faced steel burnisher.

The Forces Used in Condensing Cohesive Gold.—There are two principal forces used in condensing cohesive gold: hand pressure and blows from the mallet. These may be either alone, or one following the other, or in combination; the last named is the most popular, the least taxing on patient and operator, and produces as great specific gravity in less time. The best results are obtained, however, by using each method at given times in the process of building most fillings.

To Illustrate.—Hand pressure alone should be used in the filling of convenience angles; also when, on account of position, the force must be applied at nearly a right angle to the wall against which the gold is being condensed, as in starting a filling and when covering the seat of the cavity with the first one-half millimeter of gold.

With the plugger point pointing directly at a dentine wall, with a thin layer of gold between, the elasticity of the dentine causes the gold to rebound when struck a blow with the mallet. In such positions the closest adaptation is secured by hand pressure alone, which should be applied with a rocking motion. This is secured by swaying the outer end of the plugger from side to side for a distance of about one inch at each change of position.

Hand pressure alone is also of service when packing gold against thin walls; again, in cases where the condensing force should be applied at an angle to the long axis of the shaft of the plugger point, as is sometimes met with in distal cavities in posterior teeth with a distal inclination. Hand pressure alone is required when it becomes necessary to use force at an angle which would tend to unseat the filling.

A filling should never receive a blow through the plugging instrument when that instrument does not point quite directly toward one of the inner walls of the cavity, preferably the seat.

Mallet force alone is of service in adding the last portions of gold to an occlusal surface, when adding thin layers of gold each time. This results in a very hard surface.

A good rule is to increase the hand pressure (load) both in frequency and weight as you increase the thickness of the pellets applied and as the angle at which the gold is driven to a dentine wall approaches a right angle.

The Different Plans of Mallet Force

Hand Mallet.—By far the best mallet force is the hand mallet driven by an experienced assistant. By this method the operator is able to vary the amount of hand pressure (load) and its relation to the mallet force (velocity) at will all through the filling, as well as at different points in the condensing of a single pellet of gold, a point of no small consequence.

Automatic Mallet.—An attempt has been made to imitate this combination method in the automatic plugger, which is today the best substitute for the hand pressure and assistant mallet method, but it must be regarded as a substitute only, which supplies a need in the absence of better facilities.

Power Mallet.—Power mallets, either electric, or mechanically driven by the engine, are of service in that part of each filling where mallet force alone is indicated, as previously described. But this is such a small proportion of each filling that most operators do not care to bother with power mallets and few have them at hand. There is a deficiency in specific gravity of 0.6 by this power packing method.

CHAPTER XXV

MANIPULATION OF COHESIVE GOLD IN THE MAKING OF FILLINGS BY CLASSES

Class One. Pit and Fissure

This class of cavities is the easiest of all in that they are surrounded by solid walls of dentine, with generally only one wall missing which is the means of access to the cavity.

Starting the Filling.—In the case of a small pit cavity it is generally well to start with a piece of gold that is sufficiently large to more than cover the internal wall, and first to condense the greater portion with a rather large plugger point, using hand pressure alone on this piece. With occlusal cavities the inner wall is the pulpal wall. When the cavity is in an axial surface it is the axial wall.

A second pellet of gold may be added and condensed in the same way. The mallet force should now be used on a smaller plugger point, going entirely around the cavity close to the walls. The shaft of the plugger should be held at an angle of about 12 degrees to the wall against which the condensing is being done.

In occlusal cavities the condensing should be in the central portion first, then next to the distal wall, then along the buccal and lingual walls, and lastly along the mesial wall. This plan of procedure pertains to each separate layer of gold as it is applied when treating simple occlusal pits.

In buccal cavities the order of stepping is first, central; second, gingival; third, distal; fourth, mesial; fifth, occlusal.

When the cavity has a long irregular outline caused by the following out of one or more rather long fissures, the plan is the same, except that the most distant arm of the cavity is filled first. The gold is gradually built toward the operator's viewpoint, covering the base wall portion by portion, with the plugger point always at the given angle to this base wall. This permits the use of mallet force after the first pieces of gold have been securely anchored along the distopulpal line angle.

Class Two. Proximal Cavities in Bicuspids and Molars

Beginning the Filling.—There are three distinct methods of starting a filling of cohesive gold in this class of cavities. It is well if both gingival point angles are sharpened to a convenience angle. It will not suffice to have these made into the form of a round hole or slot, but they should be shaped up to a distinct wedge. This shape will cause the condensed gold to crowd the elastic dentine on all sides as it is driven to place and will insure the stability of the first piece of gold. If this small convenience angle is not sharp at its deepest point but has a flat wall or seat, the mallet force is precluded as the elasticity of the flat wall will cause the gold to rebound when struck a blow; whereas, when this point is sharp and the approaching sides leave a wedge-shaped opening, the gold is firmly grasped when driven to position. Attention to this small detail will make easy the starting of such fillings.

Three Plans of Starting Class Two.—*The first plan,* and probably the most popular, is to fill one convenience angle, the one the farthest from the viewpoint of the operator, and, while supporting this in position with a suitable instrument, build along the gingivoaxial line angle to the other point angle.

A second plan is to fill each point angle separately and join the two with a third piece of gold laid along the gingivoaxial line angle.

A third plan is to start with a quantity of gold sufficient to fill both point angles and cover the connecting line angle as well as a considerable portion of the gingival wall next to the axial. This last plan is one used by some experienced operators and is a good one to attempt when working for speed. The beginner will do well with the first plan.

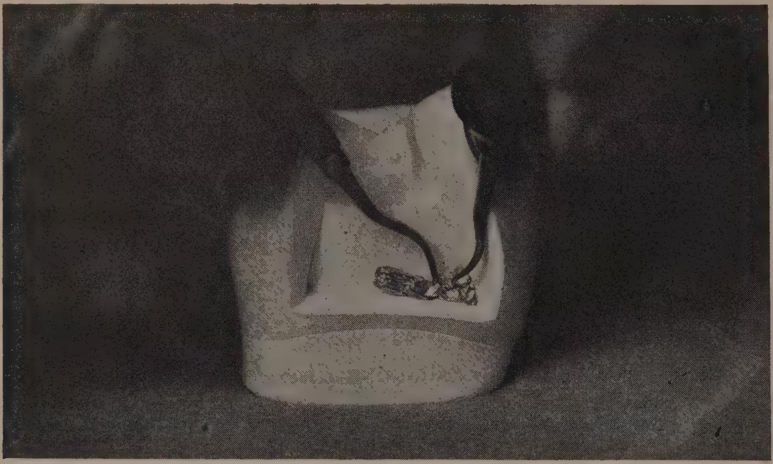


Fig. 60.—Starting cohesive gold, first plan.

The Order of Stepping the Plugger in Class Two.—With each pellet of gold added, the wedging principle is made most effective by the following order of stepping: center of filling, first; contour, second; ascending line angles, third; surrounding walls, fourth; and against ascending cavosurface angles, fifth. The long axis of the plugger shaft should be kept at an angle of about 12 degrees to the axial, buccal, and lingual walls.

When the gold extends beyond contour, it should be burnished back to correct position and the plugger again stepped along the contour, being held close to a line of the long axis of the tooth, instead of striking the gold at nearly a right angle to this line, a practice so common with operators, and one that has a tendency to unseat the filling and separate the layers of the filling already condensed.

The progress of the filling should be kept on a plane parallel to the plane of the gingival wall until near the completion of the filling, strict care being taken as to complete contour in the proximal as the filling advances.

Covering the Pulpal Wall.—There are two plans of covering the step portion in Class Two. *The first plan,* the most common, is to build the cavity portion to a level of the pulpal wall and gradually to cover the pulpal wall by allowing each pellet of gold to extend a little farther than the previous one until the pulpal point angles have been reached.

The second plan is to start an independent body of gold in the pulpal point angles, in one of the three ways outlined in starting the cavity portion on the gingival wall, finally uniting the two portions of the filling. Whichever plan is used, nothing should be done in the way of covering the pulpal wall till the gold in the cavity portion has reached a level with the axiopulpal line angle.

The Contact Point.—The building of contact point should receive special attention when the proper height of the filling has been reached. The gold should be thoroughly condensed against the proximating tooth, much in the same manner as it is wedged against the walls, and should receive extra malleting to insure extreme hardness.

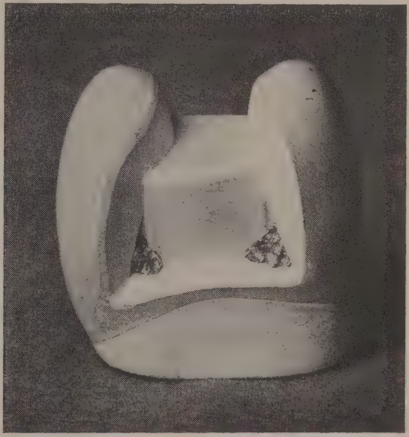


Fig. 61.—Starting cohesive gold, second plan.

Position of Contact Point.—When the proximating tooth is intact, the contact point should be in about the same position as it was previous to decay, and should be a point and not a surface or a line of contact. It should round away from this point in much the same manner as do the surfaces of two marbles when touching, and for this reason has come to be spoken of as the "marble contact." (See Fig. 30.)

Moving Contact Point Flush to Occlusal.—The contact point should be moved occlusally when both proximating surfaces are to be restored, the one being a mesial and the other a distal filling in the teeth making up the proximal space under consideration, and when there has been considerable occlusal wear. This will result in a contact point from which the surfaces round away in all directions except toward the occlusal surface, and is known as the "half marble contact" advised for the above condition only. In this connection, attention is called to the immunity to decay of proximating surfaces where the "half marble contact" has been produced by occlusal wear. Many instances are seen where caries already started in such spaces has ceased to progress because of the cleanliness of such surfaces, due to the lack of the penetration of food substances.

The Last Portions of Gold.—After leaving the contact point, the last portions of gold are added to restore normal contour or a condition as near that as occlusion and articulation will permit, giving special care to complete covering of the cavosurface angle at all points.

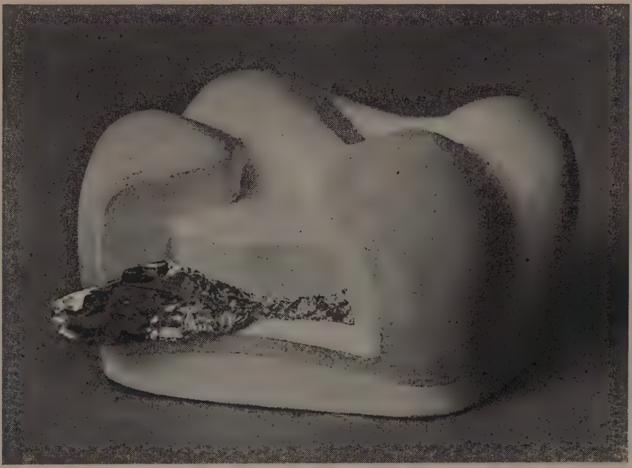


Fig. 62.—Starting cohesive gold, third plan.

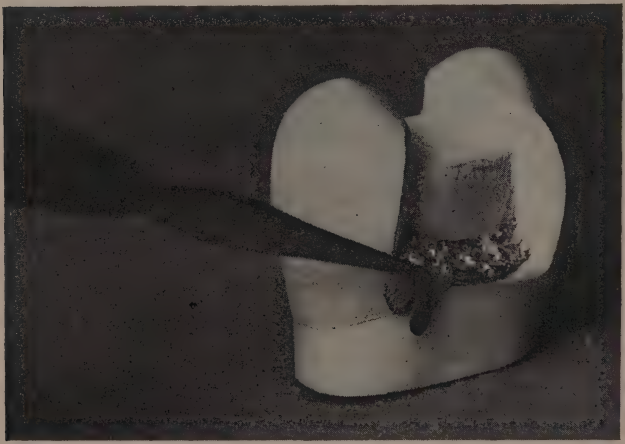


Fig. 63.—Burnishing back excess gold foil in covering the gingival margin.

Filling Class Two With Matrix in Position.—This may be done, and is advised by some operators who advance the theory of additional condensation due to the presence of the substitute for the missing wall.

When the matrix is used, it should not be adjusted till the gingival cavosurface angle is covered. It should be thoroughly wedged at the gingival.

The matrix should be removed just before the gold has been built to the height of the contact point.

The Use of the Separator in Class Two.—In cases where preliminary separation has not been made, a mechanical separation should be adjusted and tightened at short intervals to the full extent of safety. This will permit better and more thorough finishing of the contact point, as the slight space resulting will be taken up upon the removal of the separator.

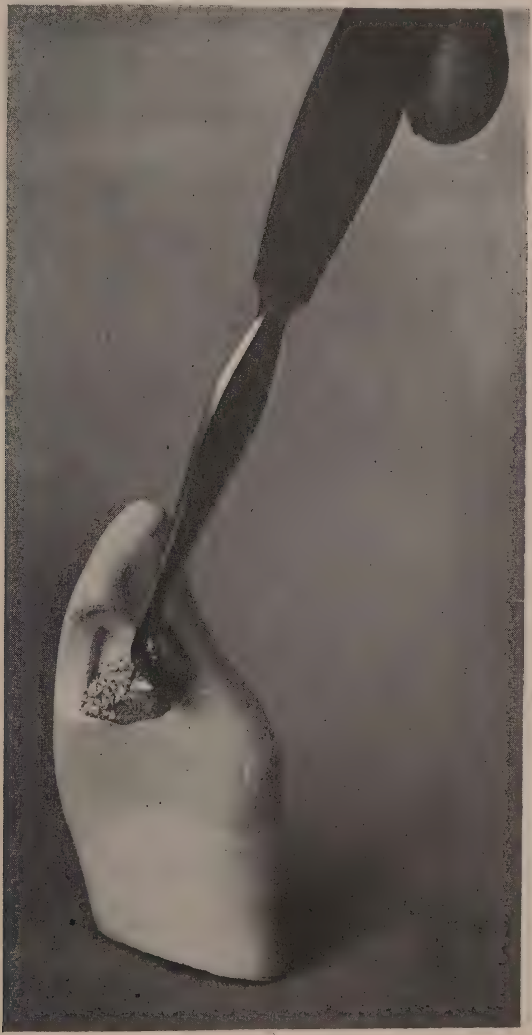


Fig. 64.—Covering the gingivolingual angle with cohesive gold.

Class Three. Proximal in the Six Anterior Not Involving the Angle

Starting the gold, in Class Three cavities, is the same in large or small cavities. The gold is first condensed into the wedge-shaped convenience angle farthest from the viewpoint of the operator, which is the gingivoaxiolingual angle. The gold is kept in this triangular form by covering equally rapidly the three walls forming the angle, the gingival, axial, and lingual walls, keeping the shaft of the plugger pointing all the time at the point angle primarily covered.

When the gold has been built out along the gingivolingual line angle to the cavosurface angle, great care must be taken at this stage of the filling that the linguogingival angle is covered and the gold built to full contour, as this is the only time it can be done correctly with the force directed in the right direction. As the gold reaches the height of the gingivoaxiolabial angle, this should be thoroughly filled and the filling continued, maintaining the same level of the gold, restoring full contour past the contact point which should be well condensed and burnished.

Filling Incisal Angle.—Shortly after passing the contact point the gold should be advanced along the axiolingual angle to the incisal angle, which should then be filled, using hand pressure alone as the direction of the force will not permit of the use of the mallet. The filling should then be completed, with the plugger point still directed toward the angle where gold was first condensed, the last portions of gold being added to the labial portion of the filling at the incisal extremity.

With lingual approach in Class Three, the whole plan is reversed. The gold is first built into the gingivoaxiolabial angle. The plugger point is maintained in a position pointing at this angle as the filling progresses, till the last additions of gold are made to the lingual surface at the incisal extremity. All the while, the operator is working according to the image reflected in the mouth mirror.

The lingual approach is advised in cases where ample preliminary separation is secured, or when the lingual wall is wanting and the axial wall meets the lingual cavosurface angle. What has been said about the use of the mechanical mallet for Class Two applies to Class Three with equal force.

Class Four. Proximal Cavities in Incisors and Cuspids Involving the Angle

The removal of the incisal angle permits the plugger point to be used in an ideal angle to the walls, and allows the force to be applied more nearly from the direction that the subsequent force of service is received.

Starting the Filling.—These fillings are started as has just been described for Class Three; however, the gingival wall should be most rapidly covered, and the plan of building similar to that described for Class Two used, keeping the surface of the gold parallel to the plane of the gingival wall, restoring lost contour as the filling advances, and maintaining the plugger point at about 12 degrees to the surrounding walls.

The final portions of gold should be condensed on the extreme incisal angle, with the shaft of the plugger point still maintained at an angle of 12 degrees to the plane of the axial wall.

The layers of gold in Class Four should receive some attention, and what is said in this connection is true of all contour restorations subject to great stress. Not a little trouble has been experienced in the breaking of such fillings through given lines of fracture.

These should be noticed and the layers of gold leaf so placed as to cross these lines. The tensile strength of the sheets of gold is greater than the usual cohesion obtained, giving a filling more strength across the laminations than parallel with them.

Class Five. Cavities in the Gingival Third

Class Five cavities in the gingival third need no special mention as they are built under the rules already outlined in Class One.

The gold is usually started in the distoaxiogingival angle and carried along the gingivoaxial line angle to the other gingival point angle. The gingival wall will be the first wall to be completely covered. The mallet force should not be directed at a right angle until that wall has been covered with a considerable layer of gold.

Class Six. Abraded Surfaces

These cavities are built the same way as large flat cavities in the same surface, the principles of which have been given.

CHAPTER XXVI

FINISHING GOLD FILLINGS

Secondary Condensation.—When a gold filling has been built to its full size, the entire surface should be gone over with a plugger point of moderate size. The point should be stepped so as to cover every accessible part of the filling.

A light mallet with a hard surface should be used. A 2 ounce steel-faced mallet is preferred.

Burnishing.—All accessible parts of the surface should then be thoroughly burnished with a steel burnisher. The egg-shaped burnisher is in most universal use as it will reach most positions.

If the filling is a proximal filling of Classes Two, Three, or Four, a thin steel hand matrix should be forced between the filling and the proximating tooth to burnish the contact point and to better condense and harden the filling at this place. This is done by swinging the handle back and forth, describing the part of a circle, till there is more or less freedom of movement of the burnisher.

Following this secondary condensation the process of smoothing the surface with abrasives begins. The first effort should be to find the cavity outline; the second, to correct contour in localities where an excess has been built; and the third, to polish the contact point.

This is best accomplished by the use of small carborundum stones on occlusal surfaces, disks on buccal, lingual, and labial contours, and narrow coarse strips in the proximal, gingivally from contact point assisted by the use of file cut burnishers.

Attention should first be given to all parts of the filling except the contact point, which, in all proximal fillings, should be the last place to receive finish.

The use of the saw in the proximal space in the finishing of the filling cannot be too strongly condemned. In the first place, no cutting instrument, or coarse abradent, as strips or disks, should be made to pass the contact point except where there has been ample preliminary separation and the return of the teeth to position is relied upon to close the resultant space. Again, there is no excuse for building an excess of contour sufficient to engage the bite of a saw blade.

The excess at the gingival should be slight, and, with the excess fullness in the embrasures, should be filed away with the files, or whittled off with the burnishing knife, the edge of which should be keen. The files should be carried through the embrasures as far toward the center of the filling as possible and drawn directly outward and over the edge of the filling to the external enamel surface.

The finishing knife should be engaged into the substance of the gold and drawn from the gum and at the same time outward, taking off only a small portion of gold at each cut.

Coarse abrasives, as carborundum stones and coarse disks and strips, should be abandoned as soon as a near approach to the cavosurface angle is reached, and the files, plug-finishing burs, and knife-edged instruments should be resorted to, to bring into view the exact cavity outline, after which the finer strips and disks should be employed to bring gold and tooth substance to an exact level at the cavosurface angle for the entire cavity outline.

Finishing Strips in the Proximal.—To reduce the quantity of gold from contact point to the gingival, a coarse finishing strip, sufficiently narrow to reach from the gingival outline to near the contact point only, is of advantage. This strip is introduced by sharpening one end and passing it through the embrasure below the contact point and then drawing it back and forth till the desired surface is secured. Fine narrow linen strips are then used in the same way to give a final finish to this place of difficult access.

When the entire cavity outline has been exposed and the surface otherwise made ready for the final finish, the separator should be tightened another degree, when it will be found that a broad fine linen strip will easily pass the contact point. This should be given three or four sweeps with this broad strip not too tightly drawn, when the contact point should be considered finished.

The separator should be gradually loosened and removed, the rubber dam removed, and the filling tested for occlusion and articulation and properly shaped. The filling should then receive a thorough finish, with wood points, leather wheels, and tooth cleaning brushes, carrying first pumice, then whiting, till the surface of the filling is as smooth as the external enamel surface.

CHAPTER XXVII

SILICATE FILLING

A Synthetic Porcelain

Definition.—The term "silicate" as applied to a class or kind of filling for cavities in teeth is one finally reached, with common consent, by the members of the dental profession, the research laboratories, and writers, as well as various manufacturers, when referring to this product.

This material is by no means a cement, as its use will not "make bodies adhere together," and such use is no longer advocated.

This material is largely a silica and is changed to a silicate by a synthetic process termed silicatization.

The term "porcelain" is a little far-fetched in this connection, yet no more so than when we say "fused porcelain" in referring to the glazed material as a filling.

Composition.—The mortar is produced by bringing together to complete mortarization a powder and a liquid. The resulting reaction gives an end product which is both a chemical compound and a mechanical mixture.

The powder is composed of both soluble and insoluble substances, when combined with the fluid.

The powders of the acceptable makes, as shown by a qualitative analysis, are largely composed of silicon (Si), aluminum (Al), calcium (Ca), fluorine (F), sodium (Na), and phosphorus (P), with one containing iron (Fe), and one containing (Sr).

The Fluid for Silicate.—Of the six accepted makes, all are composed of phosphorus (P) in aqueous solution, and, in addition, four have aluminum (Al), and two have magnesium (Mg).

No account is made of the coloring matter and minor constituents showing less than 0.1 per cent. The arsenic (As_2O_3) content is slight and is much less than in zinc oxide cement, universally used to set crowns and inlays.

The first experience in the use of this filling material by the profession showed that there was a wide range in durability in the same mouth with material taken from the same bottles using the same technic, or using different makes and technic. Some lasted two years, some ten, fifteen or twenty, and more.

A confusion has resulted because of a great variance in instruction by the several manufacturers. Each maker startles us with a radical departure from previous technic. We read that you should use a cold slab, a warm slab, a smooth slab, a rough slab, a stellate spatula, a bone spatula, an agate spatula, a stainless steel spatula; that there should be a thin mix, a thick mix, a medium mix; that the powder should be added fast, or in small portions.

Similarity of Formulas.—With such a similarity of the component parts as shown by both qualitative and quantitative analysis, there should be a reasonably similar technic used in mortarization and manipulation, based on the inimitable laws of chemistry and physics, to the end that quite uniform results be obtainable.

Fundamental Facts.—First, it is the powder which gives durability. Second, complete mortarization must be secured on the slab. Third, the combination is both chemical and mechanical. Fourth, manipulation should be completed before crystallization starts. Fifth, the less the size and number of voids, the more resistance to extrinsic enemies. Sixth, if the contents of powder and liquid are right to start with, it should not be different to end with. Seventh, since the liquid is a most unstable compound when exposed to air, there can be no balanced liquid. Eighth, all silicates shrink on setting, particularly during the first three to five minutes, as jellying takes place.

When silicates are tamped to place or set under pressure, the voids lessen in size and number in the proportion of 26 to 37 and are driven toward the center of the filling, leaving an external crust.

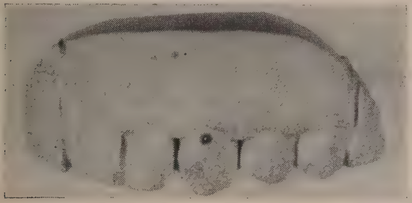


Fig. 65.

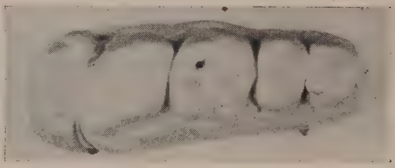


Fig. 66.

Fig. 65.—Silicate filling, Class Five. Placed in cuspid in 1910, or thirty-three years before model was made. Black dot indicates center of filling.

Fig. 66.—Silicate filling, Class One. Placed in first molar during 1910, or thirty-three years before model was made. Black dot indicates center of filling.

Dates of Introduction.—During the year 1910, we became interested in American-made silicate. In 1913 we presented a paper to the National Dental Association, ''Synthetic Porcelain Using Mallet Force for Introduction,'' which was published the same year in *The Dental Cosmos.* Figs. 65 and 66 show two such fillings placed during 1910, or 33 years before photographing. They are as placed at the time of writing this chapter.

There have been but few changes made in the technic as advanced at that time. A colder slab, more tamping and greater confinement while setting, and greater care in protection from moisture have been stressed.

This technic has been applied to each make as it has appeared on the market, ignoring the sales talk of instructed vendors, with gratifying results. (See Figs. 65 and 66.) These are not of the same make. The technic here taught was used with all makes.

Research on Silicates.—During the year 1937, the author was requested to collaborate with the Bureau of Standards relative to silicate technic. Our findings were requested on fourteen presented problems. We added three of our own. We carried six different makes through, discarding one as unsatisfactory.

The varied humidity, and the room and slab temperatures were noted and recorded, whether they were incidental or created.

With all makes, the technic herein advocated was checked against the various technics advocated by the manufacturers. Mouth conditions were simulated as nearly as possible in the use of an electric culturing oven containing a humidity-controlled compartment.

The only thing in connection which was constant was the use of 0.2 c.c. of liquid discharged from an accurate valve syringe.

Summary of Findings.—As details of research are tedious, in order not to take up the time of the reader or student, we will give only deductions from our records.

Increased Powder Content.—By using a slab at a temperature of 40° to 60° F. and paddling the mix on the slab as a final act, we were able to increase the amount of powder incorporated by from 40 to 100 per cent over that possible when following dealers' printed instructions.

Mixing Time.—The mixing time as advocated by the dealers is correct for this technic, varying from one minute to one hundred seconds.

When the powder is added in great amounts in a shorter time, much less powder can be incorporated, and when the time of spatulation is extended by even one minute more than proper, the setting is slowed to thirty minutes or longer. The primary jellying is broken up, resistance to crushing strain is lowered, and voids or air spaces are increased.

Rate of Powder Incorporation.—The greatest amount of powder (1,050 to 1,250 mg. powder, 0.2 c.c. liquid) could be incorporated to complete mortarization by adding about one-fourth of the total at first, followed at intervals by one-eighth at a speed to stay within the time limit. Larger portions than this cut down the amount of powder possible of incorporation, and smaller portions slowed down the time of setting beyond that desired.

Exposure of Liquid to the Air.—Six drops of each make of liquid were placed on their advocated slab, left exposed to the air for twelve hours at a room temperature of 74 to 78° F. and a relative humidity of 20 to 30. At the end of this time each was mixed according to the printed directions of the manufacturers and left on the slab at room temperature, covered with the coating advised for each. One make set in five and one-half hours and another in thirty-six hours. The four others were not set enough in eight weeks to resist the Gilmore 1-pound needle. The fluids had given up some of their water content to a dry air.

Placing the exposed liquids in the humidifier with a saturated humidity (100), the effect is the reverse. All will set so quickly they are not usable. The fluid has increased in bulk by taking on H_2O. There is no balanced fluid.

Effect of Temperature on Setting Time.—Removing the mix from a cold slab to a mouth temperature hastens the setting by a few minutes only.

Effect of Moisture on Filling.—Moisture coming in contact with a freshly placed filling swells the surface, creating a spongelike condition. This fact was taken advantage of at one time in an attempt to prove that a particular brand of silicate did not shrink on setting.

The translucency varies with the different makes and with different mixes and technic in finishing. The desirability of translucency in a particular filling will bear your careful consideration in each case.

Effect of Premature Exposure to Saliva.—The opacity was increased in all, but to the greatest extent in the two using a liquid of greater specific gravity, caused by the surface expansion and deterioration. None were so affected provided they had been protected for thirty minutes after mixing.

Effect of Contact With the Air During Hardening.—As the air with its varying relative humidity is an influence, only those fillings could escape injury which happened to be made when the fluid balanced with the degree of air humidity at that particular time and place of course they were protected from the 100 per cent humidity of the patients' breath by the rubber dam in place.

Solubility of Silicate.—Solubility and disintegration are practically nil with all makes in any acid or alkaline conditions of density found in any mouth, when the surface of the filling has not been prematurely exposed to moisture.

Subgingival dissolution is generally due to leaky rubber dam or a moist ligature.

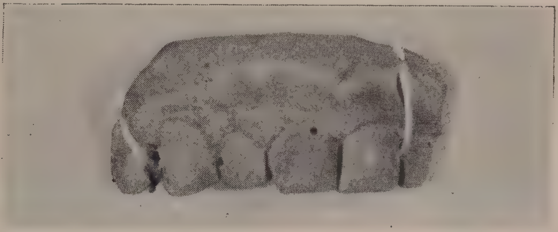


Fig. 67.—Class Five cavity was filled about eight years previously, without rubber dam in place. Class Three cavity distal to the lateral incisor was filled seven years previously with rubber dam in place. Distal to the cuspid is a gold inlay, date unknown. Black dot in center of each filling.

Acidity of Set Silicate.—All makes of aged fillings show a slight acidity, the reaction in proportion to their component liquids. This slight acidity is abhorred by the bacteria of tooth decay and probably explains the fact that we seldom see secondary decay penetrating beneath a tightly placed silicate or on the surface of an approximating tooth with sound enamel at a close contact point although abnormally broad.

Cavity Preparation for Silicate.—Generally speaking, the cavity formation to secure a silicate filling is not unlike that for other materials requiring a retentive form throughout. No silicate yet made has any adhesive or cementatory properties. There are some modifications in each class of cavity, however, that must be heeded. With all classes there must be no marginal beveling, allowing the cavosurface angle to be as nearly as possible a right angle.

In Class One cavities the instructions given in the chapter on amalgam obtains for silicate.

In Class Three cavities the rules for cohesive gold obtain except that the marginal bevel and the convenience angles should be omitted, and the labial

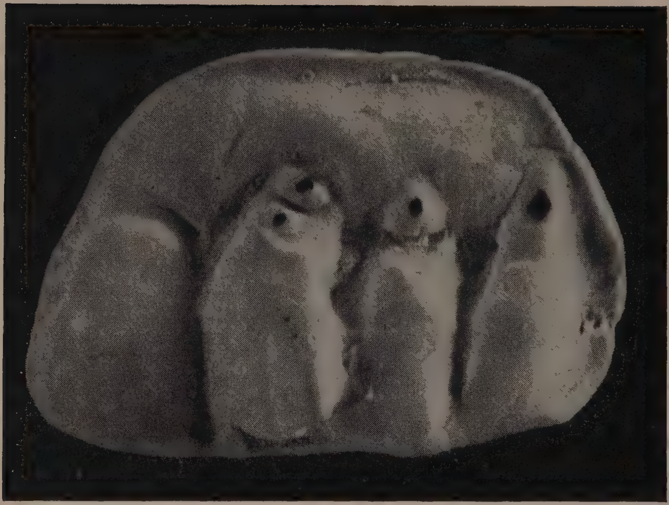


Fig. 68.—Four silicate fillings, Class Five. The cuspid was filled in 1918, the central and lateral incisors in 1914, or twenty and twenty-four years, respectively, before the model was made.

Note: Toothbrush wear has worn the teeth away leaving the fillings standing as when placed. There is no decay or discoloration.

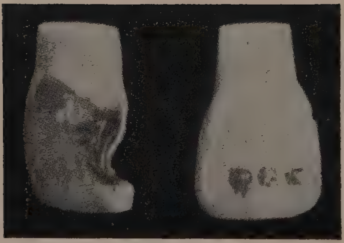


Fig. 69.

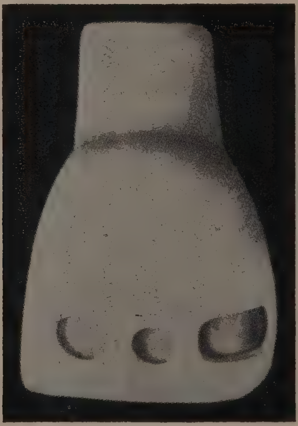


Fig. 70.

Fig. 69.—Suitable cavities for the use of silicate fillings.

Fig. 70.—A Class One cavity on the labial of a central incisor properly prepared for a silicate filling. The decays are shown in Fig. 69.

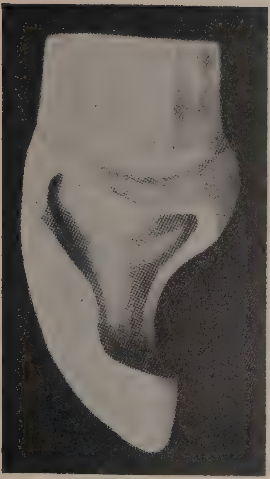


Fig. 71.

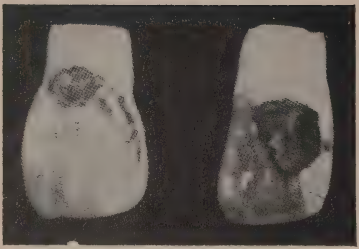


Fig. 72.

Fig. 71.—Extensive Class Three cavity properly prepared for silicate filling. Decay shown in Fig. 69.

Fig. 72.—A Class Five and a Class Three cavity suitable for the use of silicate as a filling.

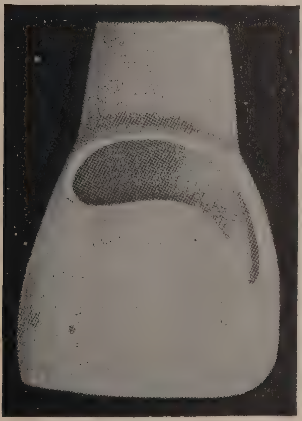


Fig. 73.

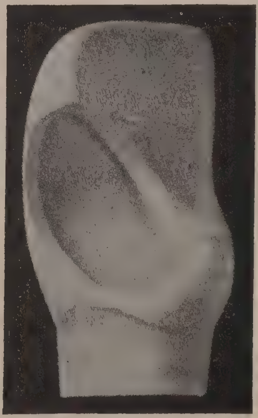


Fig. 74.

Fig. 73.—A Class Five cavity properly prepared for a silicate filling. The decay is shown in Fig. 72.

Fig. 74.—A Class Three cavity, lingual approach, properly prepared for a silicate filling. The decay is shown in Fig. 72.

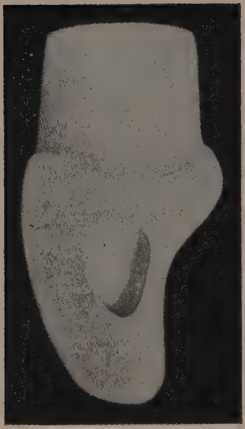


Fig. 75.

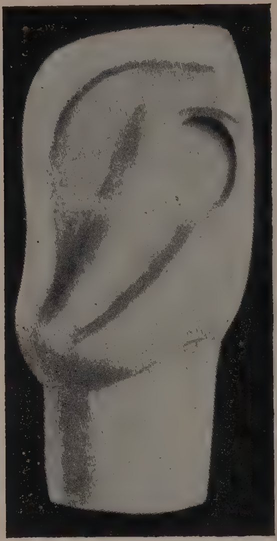


Fig. 76.

Fig. 75.—A small Class Three cavity, labial approach, properly prepared for a silicate filling.

Fig. 76.—A small Class Three cavity, lingual approach, properly prepared for a silicate filling.

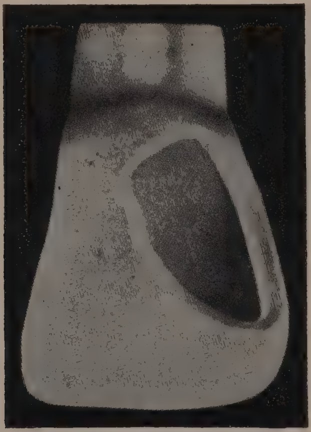


Fig. 77.

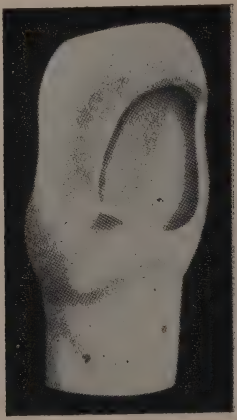


Fig. 78.

Fig. 77.—A large Class Three cavity, labial approach, properly prepared for a silicate filling. Note the irregular outline on the labial. This is not objectionable, for many times an irregular outline hides a slight deviation from the proper color.

Fig. 78.—A large Class Three cavity, lingual approach, properly prepared for a silicate filling. Note the fact that this cavity has two axial walls. This is a good form of preparation in vital cases.

and lingual walls cut away more generously, to give more free access for the tamping or compression of the filling.

In Class Four cavities we find the least use for the silicate filling as it is contraindicated in protusion, mouth-breathing, scissors, and end-to-end bite, for long slender thin teeth labiolingually and slim fillings mesiodistally unless supported by a lingual plate of gold, when it is spoken of as a ''silicate facing'' made independently retentive by undercuts in both gold and tooth. The Class Four silicate filling is therefore restricted to large cavities involving at least a third of the tooth, plan one only.

In Class Five cavities silicate fillings are indicated in all gingival third cavities where the gingival margin can be made and kept absolutely dry during the operation of filling. The cavity preparation is the same as for amalgam excepting the marginal bevel.

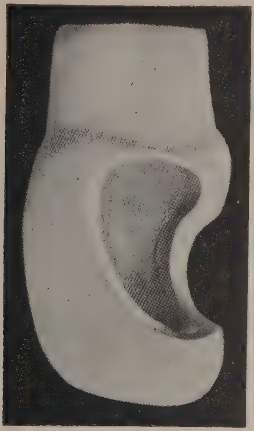


Fig. 79.

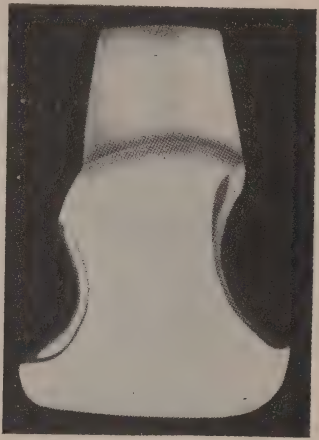


Fig. 80.

Fig. 79.—A large Class Three cavity properly prepared for a silicate filling. Note the small amount of dentine yet remaining near the incisal angle. While this angle can properly remain when using a silicate filling, it would be entirely out of the question when using cohesive gold.

Fig. 80.—Two extensive Class Three cavities properly prepared for silicate fillings. In both of these cavities the dentine has been practically all removed at the incisal angles. Cases like these may be filled with silicate but should be regarded as temporary in a large majority of the cases. The retention of these angles after filling will depend entirely upon the amount of force to which they were subjected. They would be comparatively permanent in cases of irregularity when that condition placed these angles in a position removed from stress in occlusion and articulation.

Defective enamel pits on the labial occlusal and buccal surfaces are treated as to building and setting in the same manner as the Class Five cavities and is the one material indicated above all others.

The Pressure Method.—Some silicate fillings should be set under several pounds of pressure for the first fifteen minutes. They are much more dense, due to a decrease in the size and number of voids. Also, the greatest amount of shrinkage takes place inside of four or five minutes, and the pressure causes the silicate to set firmly against the cavity walls.

Technic of Pressure Method.—With the cavity fully prepared, rubber dam in position as well as the matrix as above described, the cavity is filled and contoured slightly more than filling requirements with temporary stopping, being burnished to a gloss rather freely out over the exposed cavity margins.

The Impression in Silicate Filling.—An impression is taken of the stopping-filled tooth so as to cover all cavity margins involved, with impression compound mounted on one of the trays or appliances shown in Fig. 83.

Trays *A* are for use on the anterior teeth, filling Classes Three, Four, and Five. *B* are for use on bicuspids, Class One. *C* are for use on molars, Class One, and large contour restorations. These are all easily made by the dentist.

The instruments, an ivory separator and crown remover, shown in Fig. 84, are used to put screw pressure on trays shown at *A* and are usually found in any dentist's operating case. Trays *A* have a depression or depressions on both sides to engage the points of the instruments. The metal trays are made of 24 gauge copper sheet.

The compound should be softened in hot water and lightly soaped to prevent sticking. In using trays *A*, the impression is secured by pinching the ends of the tray tightly to the teeth with the fingers till the compound is set.

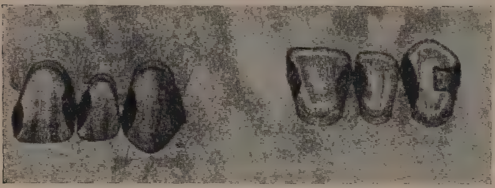


Fig. 81.

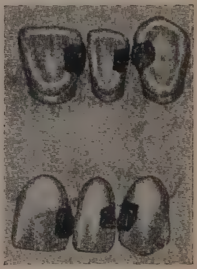


Fig. 82.

Fig. 81.—Incorrect cavity outline for silicate. Shrinkage in the first fifteen minutes causes fractures at the incisal and gingival ends.

Fig. 82.—Correct cavity outline for Class Three silicate fillings on both the labial and lingual surfaces.

With trays *B* and *C* the patient closes the opposing teeth moderately on the wood end (see Fig. 85) which is easily done with rubber dam clamp in place.

When the impression is removed, the excess is trimmed away and the surface is coated with the petroleum jelly used with that make of silicate for coating the finished filling, and then laid in a convenient place for use.

The temporary stopping is removed from the tooth, the toilet of the cavity repeated, and it is made ready for the filling.

In cases of near exposure of the pulp, the pulp must be protected with a rigid capping to shield it from the force applied later.

Making the Mix.—With all in readiness, we proceed to make the mix. One of two slabs is to be preferred: either one with a thermometer embedded, or the cold bottle which we have designed and use exclusively. Each has its advantages and for silicate work it should be chilled to 60° F. or below, preferably below.

At this point condensation on the slab must be controlled in places of relatively high humidity (Fig. 86). In mild cases this is easily done by oil fogging the slab with the palm of the hand, as will be best shown in the picture of a black slab. In extreme cases, such as near the eastern and southern seashores and aboard ships, you need the use of an air conditioning chamber.

In this chamber, the mixing may be done in an atmosphere of relative humidity of 20 to 60 degrees below that outside.

On the right-hand side place 50 or 100 per cent more powder than that advocated at this time by the manufacturers.

In the first two dumps of powder, make a depression as the servers at a restaurant do when serving mashed potatoes and pan gravy. (Fig. 87.) In this depression place 2 to 3 or more drops of liquid as needed, and do the mixing, as there will be no condensation below the powder (Fig. 88).

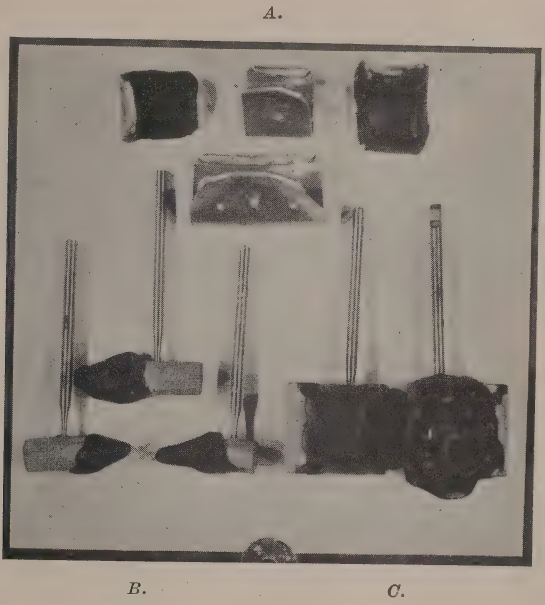


Fig. 83.

As soon as the major portion of the first 2 dumps has been incorporated, quickly add enough to produce a heavy crumbly mass (Fig. 89).

Then heap this together and strike several blows with a clean spatula. A glossy pellet should result which has only a slight tackiness that dulls on pushing the end of the spatula against the pellet and again glosses on patting (Fig. 90).

Immediately place a glass top over this at room temperature and the mix is ready for your filling (Fig. 91).

Filling the Cavity. Mallet Method.—The assistant lifts the cover glass each time you reach for a portion to build your filling.

If the material conveniently adheres to the applicator, this is an additional test for consistency. In case it cannot be so carried to the cavity, the mix does not show complete mortarization, is too dry, and should be discarded.

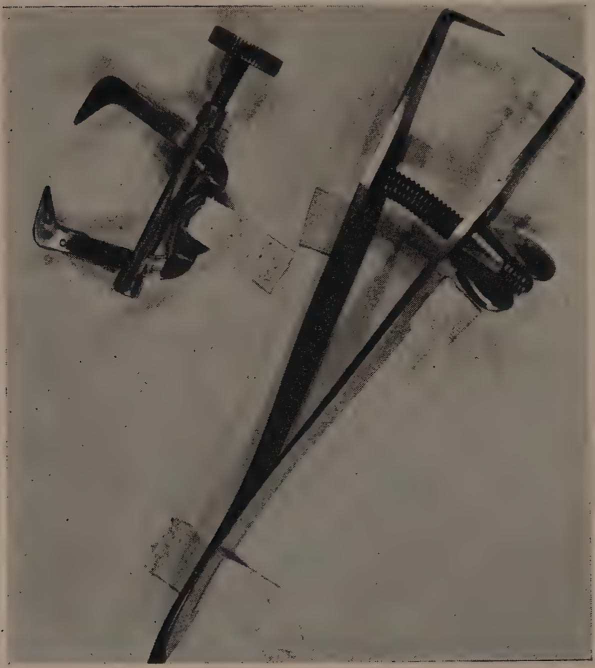


Fig. 84.

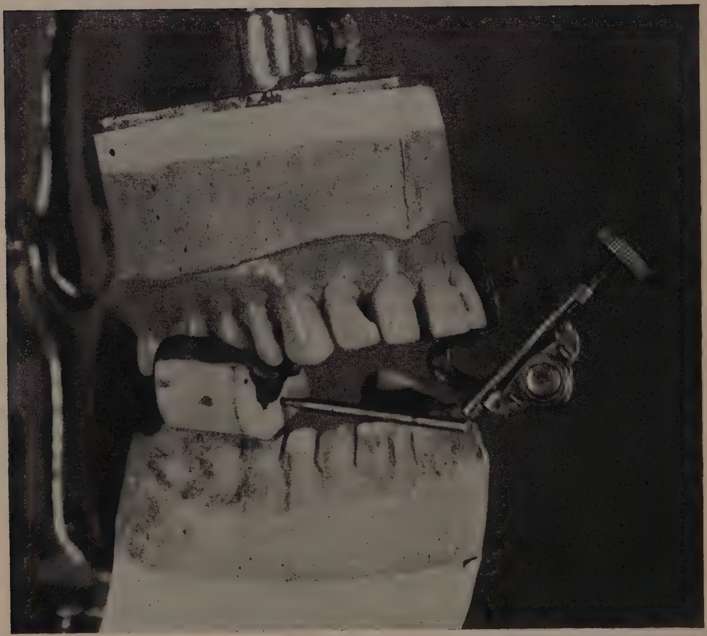


Fig. 85.—Rubber dam must be in place (not shown here).

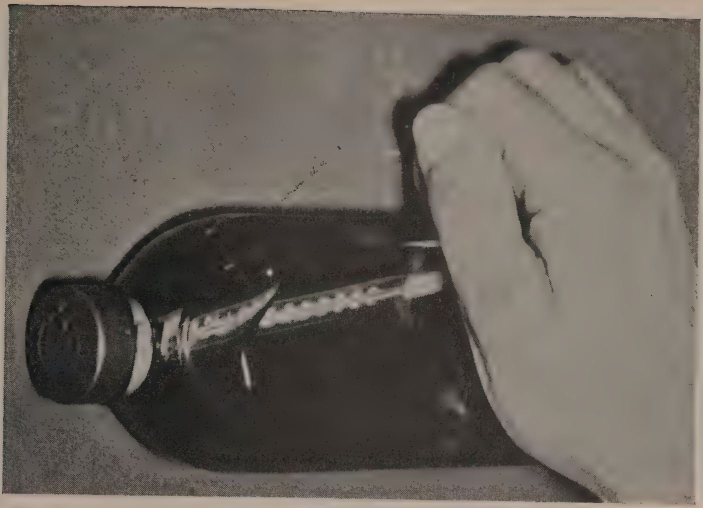


Fig. 86.—Cold-water bottle being fogged to control condensation.

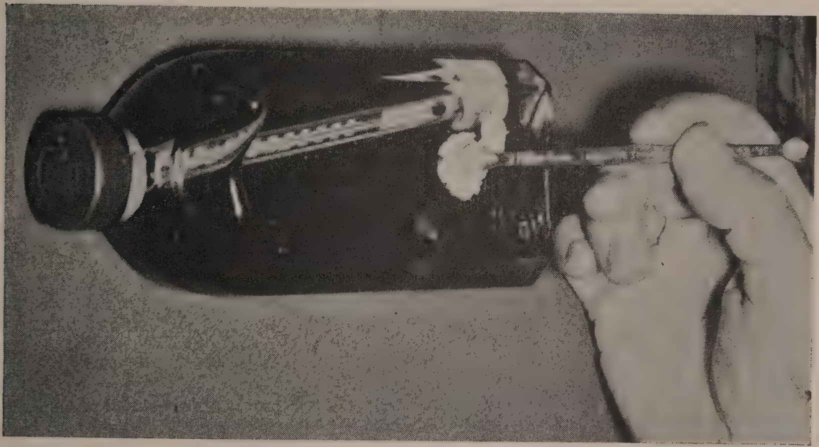


Fig. 87.—Bottle with three drops showing the making of a depression for fluid. There will be no condensation beneath the powder.

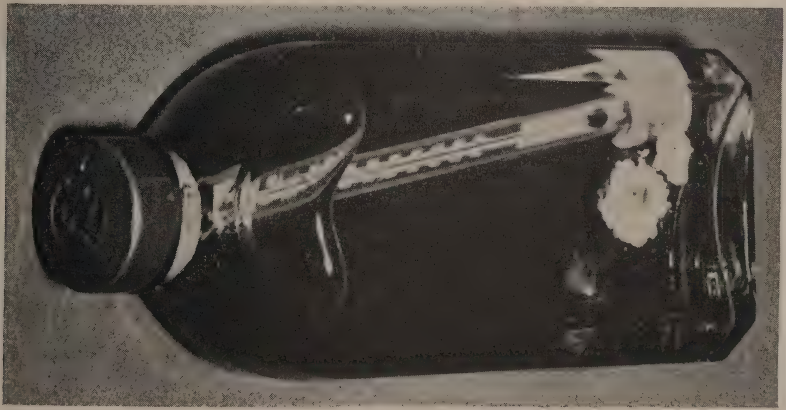


Fig. 88.—Bottle with three dumps showing the fluid in the depression. There will be no condensation beneath the powder.

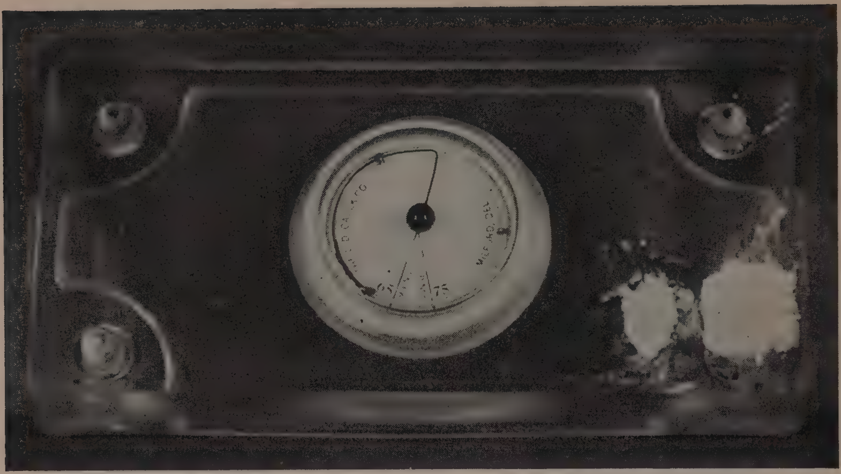


Fig. 89.—Crumbly mass.

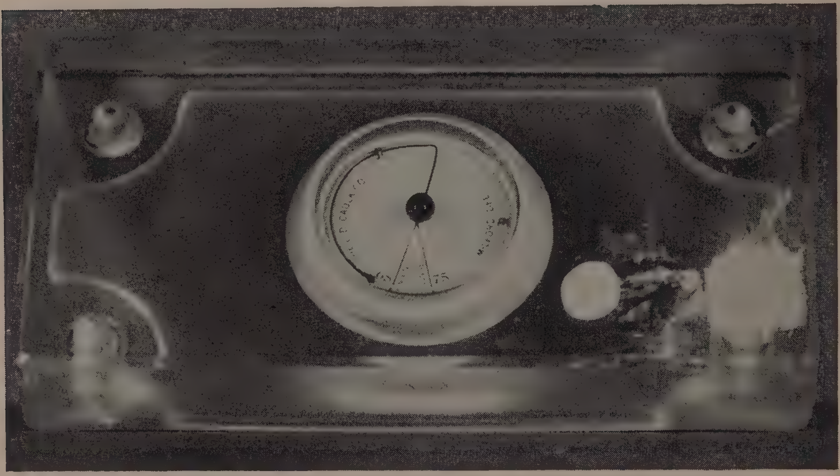


Fig. 90.—Shiny pellet results.

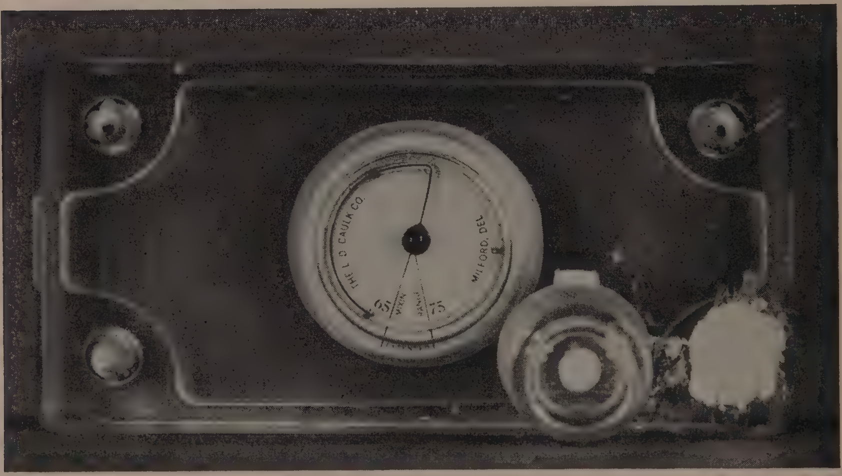


Fig. 91.—Covered with glass to shut out the air.

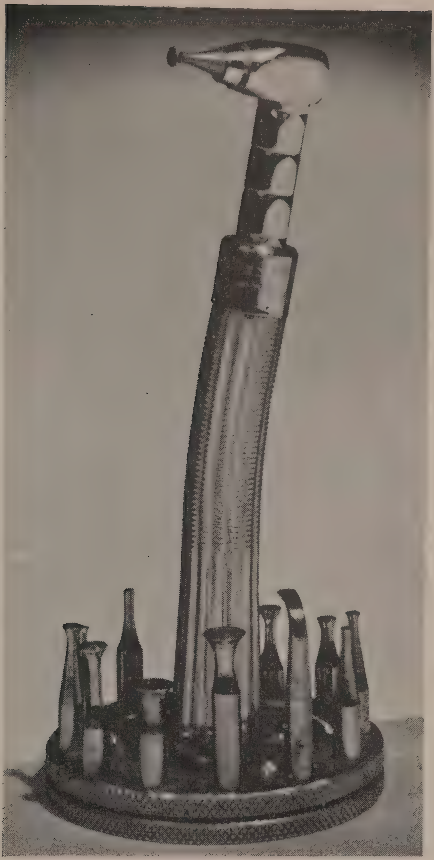


Fig. 92.—"Malletor," made by the Dudly Research Corp., 18 W. 27th St., New York, N. Y. The author has found this mallet best suited for the packing of silicate. The three points in front are for silicate. The others are used in packing amalgam.

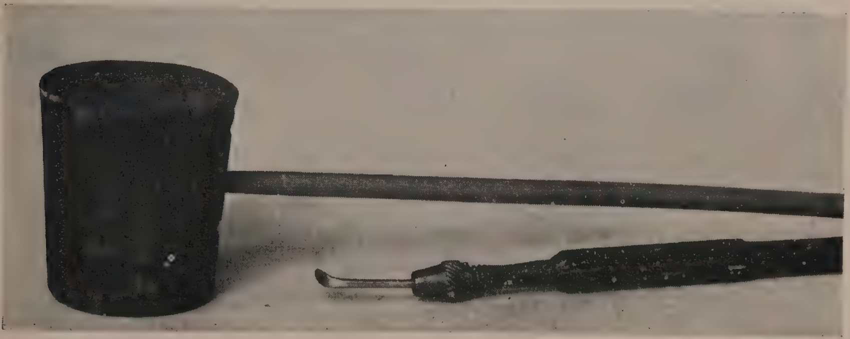


Fig. 93.—A homemade mallet and point used by the author in 1910 for puddling and jarring silicate to position in the cavity.

Fillings shown in Figs. 68 and 69 were made in this way and are still in good condition as to color and bulk.

Make the cavity more than full with about 3 applications, covering all margins and given a slightly exaggerated external shape. Immediately apply the "Malletor" carrying a special point that is larger than the cavity, the surface of which has been fogged. (See Fig. 92.) Use a very light blow, increasing the weight of the blow as the material begins to crystallize, ceasing to mallet when it feels like elastic rubber, and immediately cover completely with a petroleum jelly and cocoa butter combination. There is a reason for the combination.

The Mark Time clock has been set for thirty minutes. The mixing and placing the filling should be done in three minutes, the excess dressed away with knives and files at the ten- to fifteen-minute period, and the dam removed and moisture admitted to the heavily greased filling at the end of the thirty-minute period.

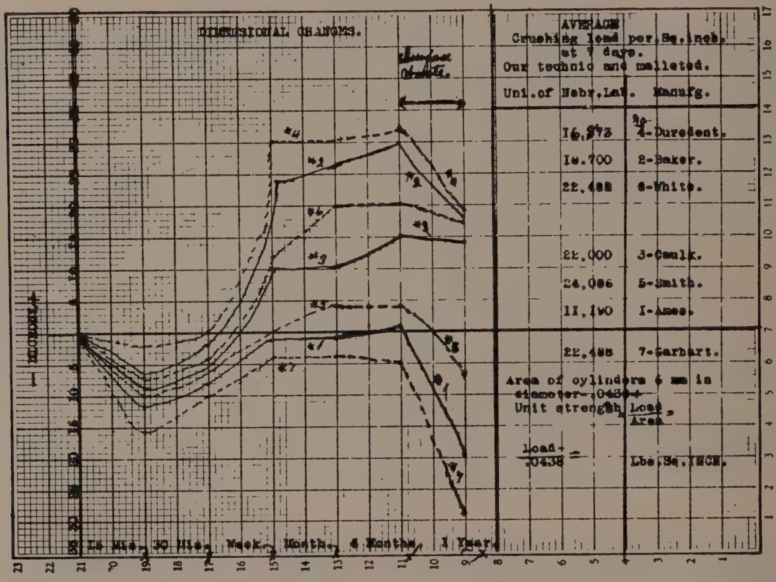


Fig. 94.—Graph showing the behavior of seven makes of silicate after fifteen minutes; after thirty minutes; after one week; after one month; after six months, and after one year. After six months, surface wastage exceeds the expansion, if any, by 1 to 25 microns or the average of about the thickness of a human hair, on a 5 mm. long cylinder.

The use of varnish or "overcoat" at the first sitting is actually injurious, as it prevents the hydrostatic expansion, the major portion of which takes place in the first few hours if it is submerged, and is practically ended in one week.

This whole procedure results in the difference between a shrinking and an expanding porcelain filling, with most makes (Fig. 94). Five of our most-used brands show hydrostatic balancing. The resistance to the crushing strain is ample with any and all makes (Fig. 95).

In these tests we used fillings made and removed from bronze dies which produced specimens 5 mm. long with a diameter of 6 mm. These were crushed

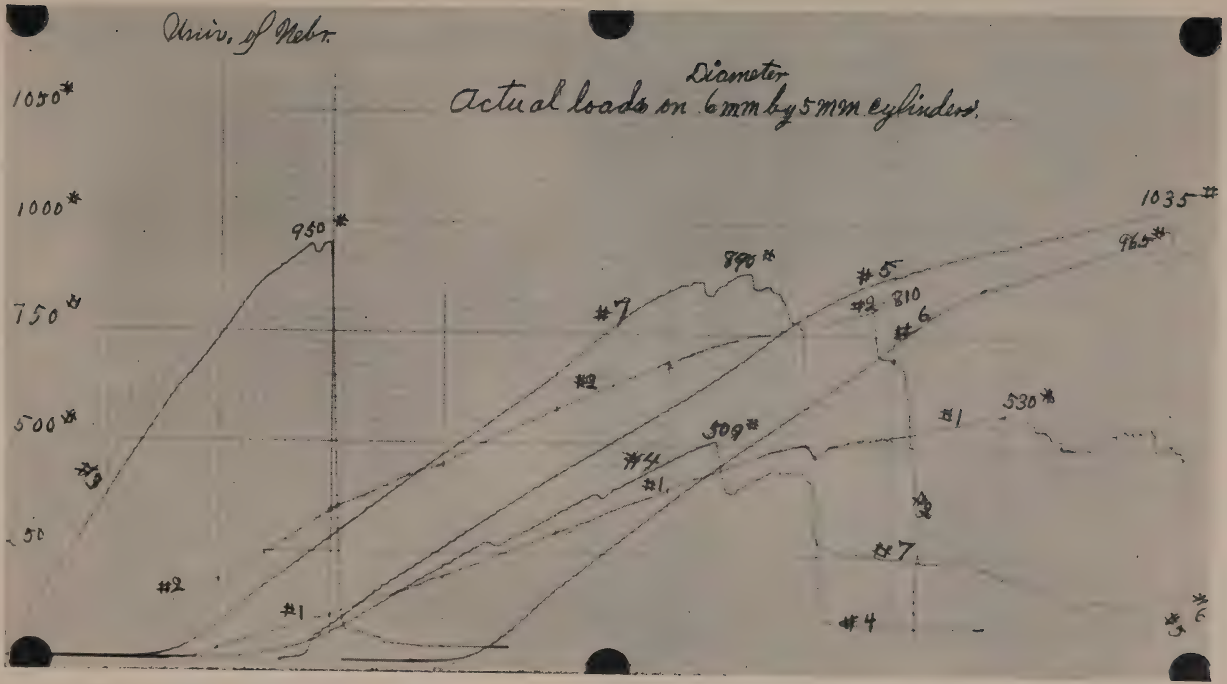


Fig. 95.—Here is shown the resistance to the crushing strain of the several makes, as shown by the Southwick-Emery testing machine of the University of Nebraska.

Five by 6 mm. cylinders were used at one week old, immersed in water.

at the end of seven days. Simulating usages in the mouth, attention was given to the temperature of room, slab, and mouth, and the time of greasing and protecting from moisture, as well as that of submerging, the latter maintained seven days.

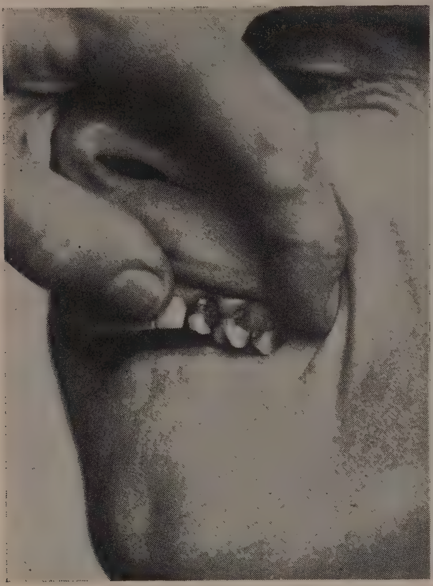


Fig. 96.

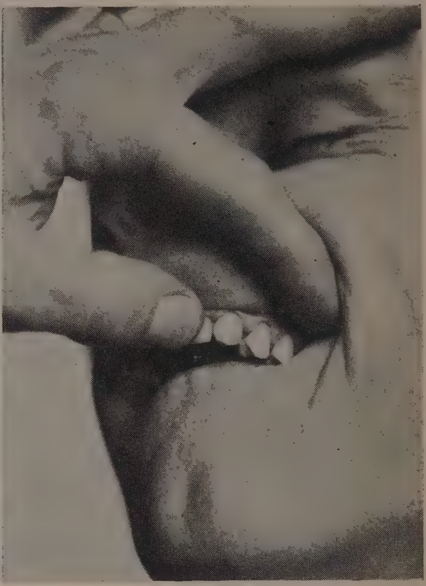


Fig. 97.

Fig. 96.—Three cavities suitable for silicate fillings.

Fig. 97.—This shows the results obtained after filling the cavities shown in Fig. 96 with silicate.

Summary

In closing, let us state some of the fundamentals which augur long life and permanent coloring to silicate fillings.

1. It is the silicate granules and undissolved particles which give stability.

2. A cold slab holds back the jellying for a few seconds to give time to incorporate a greater number of granules in the given bulk.

3. The jelly is composed of the acid and the more easily dissolved parts of the powder.

4. When mixed, the mass is about 75 per cent jelly, which is in excess of the needs for maximum strength. It therefore follows that the silicate granules are farther apart than they need be.

5. Manipulation in filling building should aim at driving off as much of the jelly as possible, bringing it to the surface to be dressed away with the excess. This can be done by tapping or light malleting as with the "Malletor."

6. The drawing over of a strip of any kind does the reverse, bringing the jelly to the surface and leaving no excess for dressing away to expose a greater number of silicate granules per given surface.

7. An absolute control of moisture is imperative, since in the early stages of setting it is the filling's worst enemy. At thirty minutes or soon thereafter

moisture is a much-needed friend and continues to be an essential factor through the life of the filling for thirty-two years at least.

8. The modeling compound impression method is of advantage only when cavities cannot be so housed that only one surface is exposed, as in Class Four cavities.

9. By this technic there are five makes which produce an expanding filling at the end of seven days.

10. Do not use varnish on a new filling as it results in a contracted filling. Use petroleum jelly containing cocoa butter at first sitting.

11. Cautions: Do not bevel the cavity margin. Always have a right angle cavosurface angle. Do not mix too thin. Do not forget to phenolize and line the cavity in vital pulp cases with an acid-proof varnish and otherwise isolate the pulp. Do not burnish or drag at the material. Always press and pat the material to place to slight excess and then subject to mallet packing. Do not remove the rubber dam till thirty minutes after mixing. Do not knead with the fingers. Such handling creates fracture lines.

12. Causes of brown lines at margin: incorrect cavity preparation; failure to clean margins; not tightly packed over margin by Malletor to drive excess liquid beyond margins into excess; burnishing and dragging margins; failure to finish flush with margin at later sitting.

13. Causes of disintegration: failure to maintain dryness of cavity and filling; evaporation of liquid either in bottle or on the slab meaning too dense a liquid; mixing too thin; mixing on too warm a slab (above 60 degrees); overspatulating; failure to protect filling with petroleum jelly as soon as filling is contoured and to keep coated thereafter, dismissing the patient with it so coated; removing the rubber dam before thirty minutes from the time of mixing.

14. Causes of chipping: faulty cavity preparation and lack of retention; placing a small bulk where fillings will receive excess load; crowding a filling to cavity through a small proximal opening; failure to mallet filling as last manipulation; kneading with the fingers; abrupt change in the direction of the cavity near margin.

15. Causes of checking: applying cocoa butter above body temperature; creating heat when finishing; filling in protruding anteriors which are not covered during sleep; failure to coat old fillings with grease during operations under rubber dam.

16. Causes of pulp devitalization: failure to phenolize and line the cavity with varnish impervious to free acid; failure to otherwise protect the pulp.

17. Causes for fillings turning brown: allowing moisture to reach the outer surface of the filling too soon, which causes the surface to swell and become spongelike, to later absorb the oils from the food substances which subsequently oxidize; smoking paper-covered cigarettes soon after filling is placed. Abstain from smoking for twenty-four hours.

CHAPTER XXVIII

FUSED PORCELAIN FILLING. CAVITY PREPARATION

Preparation of Cavities for Porcelain Inlays.—The filling of teeth with porcelain demands some change in the usual and accepted form of cavity preparation for other materials.

Access Form.—Access form reaches its maximum in porcelain fillings. Even greater access is required than for the gold inlay. Hence, preliminary separation should be practiced with all proximal fillings, and mechanical separation is of advantage when setting the filling.

Outline Form for Porcelain Inlays.—Outlines must be extended to regions of sound enamel. The obtaining of full-length enamel rods supported by sound dentine is imperative. Extending to self-cleansing margins is of additional advantage, yet not so imperative as with gold fillings, as secondary decay is not liable to take place about a porcelain filling.

The outline should not follow a developmental groove nor cross a ridge at its extreme eminence. Sharp angles in outline should be avoided. Extension for prevention as applied to the embrasures is not as great as with metal fillings.

Extension for resistance to stress at margins is more essential than with gold, due to the fragility of porcelain margins.

Resistance Form for Porcelain Inlays.—The rule for flat seats for all fillings applies equally to porcelain fillings. The use of the step in Class Four is essential, to give added resistance to the tipping strain. Margins should be extended to locations less frequented by the crushing strain.

Retention Form for Porcelain Inlays.—Maximum retention form is required in all directions except one, till the pattern has been formed and the filling made ready for setting, when retention should be added in the remaining direction. Acute line and point angles should be avoided, all angles being rounded angles till filling is made.

Convenience Form for Porcelain Inlays.—The filling of teeth with porcelain requires more cutting for convenience form than for any other method. This fact makes such fillings contraindicated many times, due to the great loss of tooth substance necessary to form the pattern and introduce the filling properly. Previous separation will overcome this cutting to a large extent with this as well as other fillings.

Finish of Enamel Walls.—All finishing of enamel walls must be completed before forming the pattern. The cavosurface angle should be a right angle as the strength of fused porcelain is about equal to supported enamel margins. If a bevel angle exists, it should be deeply buried.

Toilet of the Cavity.—This is done as with other inlay fillings, before forming the matrix or taking the impression.

Another cavity toilet is necessary just before setting the inlay. This consists in washing the cavity with spirits of chloroform to dissolve any oily substances adhering to the cavity walls. This is followed with moderate drying. Excessive desiccation is not required, and in fact should not be practiced, as the integrity of the cemental substance in the enamel is injured and liability to marginal checking is increased.

Preparation of Cavities, Class One.—Porcelain is indicated in cavities on the labial surfaces of the six anterior teeth, due to faulty enamel. These are shown as small orifices in the enamel surface, generally rounded in form, and are the result of imperfect development. The cavity should be not less than two millimeters in width at its narrowest point. A smaller cavity than this hinders proper working.

Avoid the exact circle in outline, as this will bewilder the operator as to the position when setting. In case the outline is so nearly a circle as to make position questionable, the axial wall should have a small round pit at one side to guide the operator in setting. The same is of advantage in gold inlays.

The axial wall should, in large cavities, be the miniature of the tooth surface in which it occurs. The axial wall of small cavities should have a rounded groove cut around the entire circumference.

The surrounding walls should meet the axial at an obtuse angle to relieve any undercuts before pattern is formed. When inlay is ready to set, give the cavity retention form by making the base line angles acute.

Cavities in Proximal of Bicuspids and Molars, Class Two.—Experience has taught that porcelain is not indicated in this class of cavities. Their location subjects the filling to extreme crushing strain which porcelain will not stand. The occlusal surfaces are of irregular shape and made up of a great variety of forms with surfaces in any number of planes.

This makes the right angle cavosurface angle demanded in porcelain fillings improbable, and results in exposing porcelain margins of an acute angle.

Cavities in Proximal of Incisors and Cuspids Not Involving the Angle. Class Three.—This class of cavity is suitable for porcelain inlays, which make a sightly filling when properly executed.

These cavities should be divided into three classes in accordance with three different lines of approach: first, labial approach; second, lingual approach; third, proximal approach.

Labial Approach.—This approach should be decided upon when any considerable amount of the labial enamel is to be replaced and a lingual wall is possible.

The gingival wall should be extended gingivally to include all affected enamel. It should be flat axioproximally and meet the axial wall at an angle slightly acute. It should meet the lingual wall at an angle slightly obtuse.

The axial wall should be flat labolingually and be continuous from the axiolingual line angle to the labial cavosurface angle, which results in the entire removal of the labial wall. This should meet the lingual and incisal walls at an acute angle. This incisal lingual line angle should be slightly obtuse. This results in a cavity retentive in all directions except to the labial which gives it "draw" in that direction.

Lingual Approach.—The whole general plan is reversed, resulting in the retention of all or a good portion of the labial wall and an entire absence of the lingual wall, resulting in the "draw" being to the lingual.

To resist the tipping strain, the lingual step may be added. This is done by cutting away a sufficient amount of the lingual enamel, resulting in two axial walls, one facing the proximal and the other the lingual. This creates a line angle where the two walls unite, the axioaxial line angle, which should be a rounded angle.* Just before setting the inlay, the axial wall should be slightly grooved next to the surrounding walls, except in the region of the incisal point angle.

Proximal Approach.—This method of approach should be used when the adjacent tooth is temporarily removed, or when there is ample space due to irregularities, or when an abundance of separation has been obtained.

The outline should be that of a generous curve and the enamel walls should present a flat face to the proximal. The axial wall should be flat or convex to the proximal and have all surrounding walls meet it at angles slightly obtuse. This results in draw directly to the proximal.

Cavities in Proximal of Incisors and Cuspids Involving the Angle, Class Four, Plan One.—This plan of angle restoration may be successfully accomplished with porcelain when the conditions of stress would permit of the plan being used with any other material. The cavity form is the same as that described for Class Three, proximal approach, adding the angle.

Proximal approach may be used in this instance under the same conditions. In addition thereto, the incisal approach may be used when excess separation has been produced a little greater than the length of the incisal line angle, as well as more than the thickness of the inlay measuring from contact point to the greatest depth of the axial wall, which permits the filling entrance from the incisal.

To break the cement line on the incisal edge a rounded groove should be made from the external end of the incisal line angle to the incisal cavosurface angle.

Plan Two, Class Four is not suitable for the porcelain filling as the material will not stand the strain at union of step and cavity proper.

Plan Three, Class Four.—The addition of the lingual step makes many angle restorations with porcelain practical, as the tipping strain can be well provided for by grooving in the lingual axial wall next to the distal or mesial wall owing to whether the cavity is distal or mesial. The cavity should be so shaped that the draw is directly to the incisal. The gingival wall should be flat and meet both axial walls at an acute angle. The axiolabial line angle should be acute. The lingual axial wall should be concave. The axioaxial line angle should be a rounded angle and continue out to the incisal cavosurface angle.

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*These are two axial walls that meet, forming the axioaxial line angle.

Plan Four, Class Four.—Angle restoration, the creation of both incisal and lingual steps, is most popular. The incisal step is formed in much the same way as when gold is to be used. The pulpal wall, however, should be placed farther from the incisal edge and be laid in a plan less acute to the axial wall than gold.

The angle formed by the junction of these walls, the axiopulpal angle, should be rounded. In forming the lingual step the enamel may be removed entirely to a level of the gingival wall, or only as much of the incisal portion may be removed as may seem necessary to strengthen the body of porcelain in the incisal region and resist the tipping strain.

The treble step is of service in cases where there has been extensive loss of tooth structure, particularly in pulpless cases. This plan results in a gingival wall and two pulpal walls; also, in three short axial walls placed on an equal number of levels. The gingival and pulpal walls should be made to meet the axial walls at acute angles. Each of the two pulpal walls should be grooved from the connecting axial walls, and each axial wall grooved in the central portion, resulting in a continuous groove from the gingivoaxial line angle to the incisal edge. This cavity has ''draw'' directly to the incisal.

Cavities Occurring in the Gingival Third, Class Five.—Labial cavities in the gingival third are favorite places for porcelain and should, to a large measure, displace gold. If the cavity extends beneath the gum line, the gum should be forced from position by previous packing of gutta-percha or cotton saturated with chlora-percha.

Outline form should be the same as for other fillings. The axial wall should be the miniature of the tooth surface wherein the cavity occurs. The gingival wall should be flat and meet the axial at an acute angle. All other surrounding walls should meet the axial at slightly obtuse angles. This gives a cavity with ''draw'' to the labial, the incisal portion swinging out in advance, the inlay going to place gingival portion first.

This hinge movement is slight but constitutes a valuable point in subsequent retention. Just before setting the inlay, the axioincisal line angle should be sharpened to add retention form. In cases where decay has resulted in a cavity of horseshoe form, the cavity may be filled by two distinct operations.

This is accomplished by filling the cavity with cement then cutting out half and filling with porcelain. This completed, cut the other half and proceed to fill that portion with porcelain. This results in two porcelain fillings with cement between.

One point, however, must be observed. The first portion of porcelain will necessarily slightly overlap a cement wall. Before setting, this portion of the inlay must be ground at the expense of the external surface of the filling to reverse the ''draw,'' or this portion of the remaining cavity will be found with an objectionable undercut hard to manage.

Restoration of a Portion of the Incisal Edge.—The general outline in this class of cavities when they are simply a notch in the body of the tooth, is that of the half-moon when viewed either from the labial or the lingual. The lingual enamel, however, should be removed for a greater distance rootwise, resulting in a lingual step to provide against the tipping strain. The pulpal wall should have a groove mesiodistally in its central portion and extend well up along both mesial and distal walls, with the larger cavities coming out to the cavosurface angle.

Restoration of the Entire Incisal Edge. Outline Form.—The enamel is chiseled rootwise till it is firm and will result in a thickness of porcelain at all points equal to at least two millimeters.

Retention is accomplished by the addition of pins, or a generous lingual step, or both.

In vital cases where pin retention is to be used, there should be cut a V-shaped groove mesiodistally, the spreading angles of which should come just short of the dentoenamel junction labially and lingually. Mesially and distally it should continue to the cavosurface angle. A pinhole should then be bored in the extreme ends of the groove not a great distance from the dentoenamel junction in the dentine to receive the pin. When the lingual step is to be added, the enamel on the lingual is removed additionally to a distance rootwise at least equal to the labial exposure, and also, an amount of the dentine sufficient to make the newly created axial wall meet the two pulpal walls at right angles. If pins are to be added, the holes should be bored in the floor of the pulpal wall nearer the labial surface.

In pulpless anterior teeth the pulp chamber may be rounded out and porcelain so based as to form a post of porcelain for retention. Pulpless molars are treated in the same way.

Treatment of Teeth With Malformed Enamel.—The major portion or all of the enamel can be successfully replaced with porcelain. The enamel is removed to the desired point, resulting in a gingival wall entirely encircling the tooth. Sufficient dentine is removed in the incisal region to render the largest girth at the gingivoaxial line angle which is continuous around the tooth. This leaves a peg-shaped body of dentine over which the porcelain is telescoped. The method is termed the jacket crown, and the method of construction and setting is fully described in the next chapter.

CHAPTER XXIX

FUSED PORCELAIN FILLING
CERAMIC TECHNIC FOR FILLINGS AND JACKET CROWNS*

Discussion of Dental Porcelain.—Dental porcelains have been arbitrarily divided into two classifications. Porcelain which is glazed below the fusing point of pure gold is called "low-fusing" porcelain, and that which is glazed above 1945° F. is called "high-fusing" porcelain. As the practical limit of an electric furnace of the type used in dental offices is 2500° F., the porcelain used in the manufacture of artificial teeth is not applicable to the construction of inlays and jacket crowns. Some manufacturers produce two grades of porcelain which glaze above 1945° F. and designate the lower-fusing material as "medium-fusing" porcelain.

It has been stated by some authorities that the strength of porcelain is in direct ratio to its fusing point. There was some foundation of truth in this as dental porcelain was made in the past, but it is not sound reasoning from the standpoint of a ceramic engineer.

To have maximum strength, a porcelain formula must be balanced. To unbalance the formula by adding free flux to reduce the fusing point tends to weaken the material. On this basis the older view was correct. Some of the strongest porcelains cure at relatively low temperatures, however, and the choice of elementary material is wider in the low-temperature field. It needed only some research to develop a balanced formula to make a low-fusing porcelain which would equal or surpass the high-fusing porcelain in tensile, crushing, and impact strength tests, as well as in translucency and insolubility.

A balanced porcelain does not have as critical a fusing point as a fluxed porcelain, and it will reach the highest property test more uniformly. High-fusing porcelain, however, has the advantage in that a low-fusing porcelain may be added to a finished piece of work to correct contour.

Taking the best porcelain of each type, the following chart outlines their comparative advantages. A plus (+) indicates an advantage; minus (—) indicates a disadvantage, and no choice is indicated as equal (=). (See page 160.)

Investment Method—Without Platinum Matrix.—Porcelain Investment† has been designed with a coefficient of expansion identical with that of porcelain. The material is hard enough to maintain sharp edges, and soft enough to be removed from the finished inlay. Porcelain investment is white in color, so that it is difficult to see fine margins when applying white porcelain powder, and it is therefore advisable to stain the margins with alcohol-soluble prussian blue. Neither the stain nor the investment material will contaminate any porcelain which does not contain free flux and the fusing point of which is below 2000° F.

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*That which immediately follows and much of this chapter, has been taken by permission from "Dental Ceramic Technic," a treatise copyrighted and published by the Barkmeyer Electric Lab., Inc., Chicago, Ill.

†Ransom & Randolph's "Porcelain Investment."

Physical Properties (compared)	**Low-Fusing**	**High-Fusing**
Crushing stress tests	=	=
Impact stress tests	+	—
Uniformity	+	—
Color	+	—
Translucency	+	—
Texture	+	—
Solubility	=	=
Manipulation (compared)		
Bridges	—	+
Jacket crowns	=	=
Inlays	+	—
Saddles, root tips	+	—
Correction of finished work	—	+
Reglazing ground surface	—	+
Polishing ground surface	+	—
Time element	+	—
Cost of furnace	+	—
Cost of furnace maintenance	+	—

The method of procedure is as follows (Fig. 98): In taking the impression, first mold the end of a small stick of modeling compound into a blunt point (*1*), chilling it in cold water, then reheating the surface and pressing it into the cavity (*2*). If the tip is not heated too far back, the solid portion of the compound just beyond the soft tip will serve as a plunger, insuring a clear-cut impression. The impression must be held steady, guarding against movement of the patient while the compound is soft, to prevent distortion. Next, chill thoroughly and remove (*3*). Contour restorations and large surface inlays may be made with this technic, but it will be found most valuable in making small single-surface inlays.

A narrow piece of gummed tape about ¼ inch wide and 1½ inches long is used to make a ring (*4*) to form a base for the investment material model, so that it can be held firmly in a matrix holder for the manipulation and vibration of the porcelain.

The porcelain investment is mixed with water on a glass slab with a spatula to a thick, creamy mix. This is to be painted onto the impression with a camel's hair brush (*5*), blowing off the excess to insure perfect painting free of air bubbles. Then add more investment to the mix, so as to thicken it to a putty consistency, and apply this to the impression with a spatula, vibrating it into place (*6*). The gummed tape ring is then filled with the investment; the impression is inverted upon it (*7*) and allowed to set for fifteen minutes.

The primary set of this material is slow enough to allow plenty of time for careful manipulation. Each step may be followed through carefully without hurrying the work.

When the investment material has thoroughly set, dip in hot water to remove the modeling compound and paper tape (*8*). The rough edges and the overhanging margins should be removed with a sharp blade, so as to leave the cavity easily accessible for the application of the porcelain (*9*). Dry thoroughly in a warm oven, and apply stain to the margins if desired.

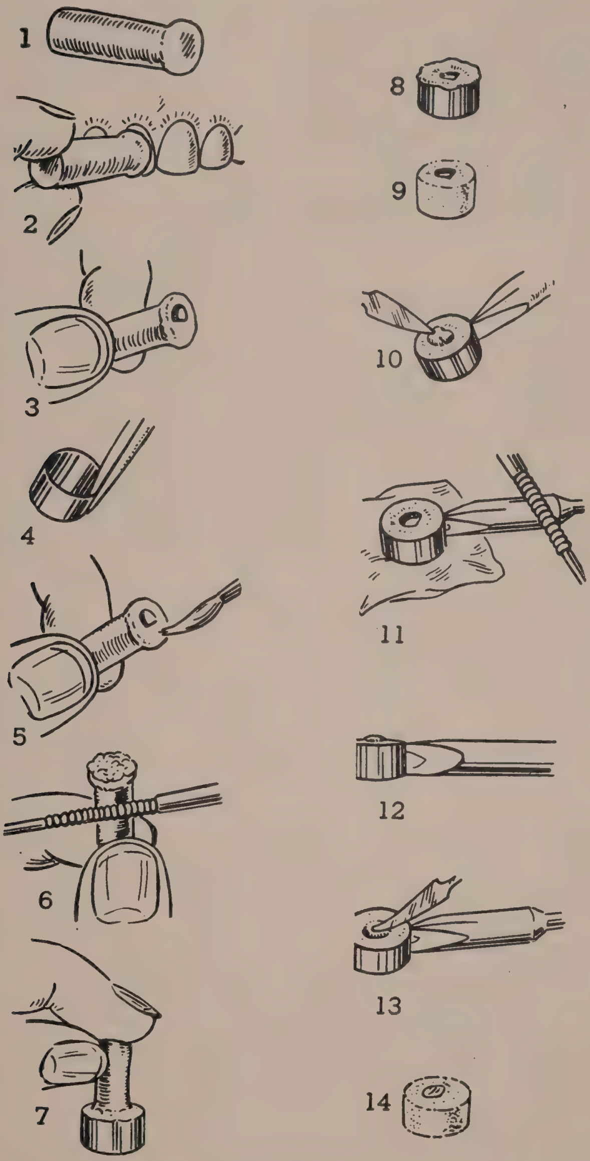


Fig. 98.

The investment model is then placed in a matrix holder, dipped in water to saturate, and the excess water blown off. The porcelain is mixed to a creamy consistency and applied, a little at a time, to the base of the cavity (*10*), vibrating the matrix holder, and absorbing the moisture through the investment with a dry cloth (*11*).

As the moisture leaves the porcelain, continue to add more porcelain, vibrating it into place, until the cavity is filled to slight overcontour (*12*). Care should be used to keep the porcelain from overflowing the margins, or, if it does overflow, the excess should be removed (*13*).

Remove the model from the matrix holder and bake the porcelain at 100 degrees below the glazing point, holding it at this temperature for a few minutes. It should be noted that porcelain requires longer to cure in investment than when glazed in a platinum matrix, due to the nonconductivity of the material (*11* to *14*).

If the porcelain has been properly condensed, this bake will show a slight shrinkage into the model, but not noticeably away from the margins (*14*). The model is stained again and placed in the matrix holder, then dipped in water and more porcelain added as before, again building to a slight overcontour. Now remove the model from the holder and bake at the full glazing temperature for about one minute. This should finish the inlay, if properly done, but if examination shows that the model needs further retouching, more porcelain may be added and baked as before. Then the model may be soaked in water and broken away from the porcelain. The material brushes off readily and leaves the cavity surface of the inlay ideal for cementation.

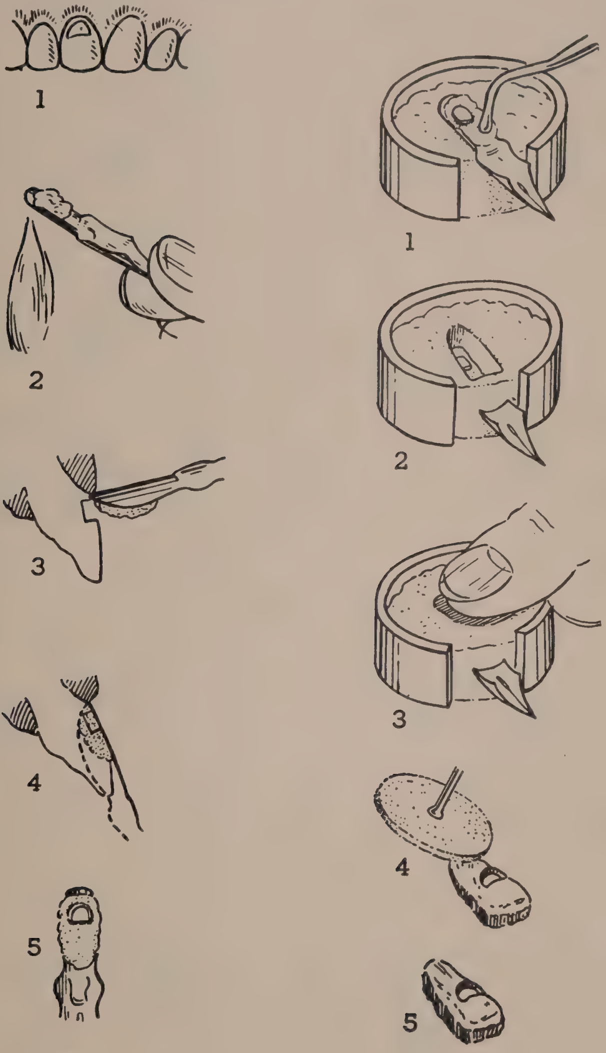
While this direct method of making inlays is quicker, it requires very careful manipulation. There is a greater hazard of error involved than with the indirect method described on the following pages, due to such variable factors as the improper condensation of the porcelain, incorrect contour, or damage to the fragile margins.

The die and matrix method has several practical advantages over the investment method, as indicated by the following points of difference: The die is a ''master model,'' on which duplicates may be made in case of error, loss, or breakage. The manipulation of the porcelain is more certain and not so delicate. The actual operating time involved in carving the porcelain is much less, and this saving more than compensates for the additional time required in making the die. If the porcelain manipulation is not perfect when made on an investment model, there is no recourse except to take a new impression. When a die has been made, it is an easy matter to carve another inlay on a new matrix.

In using the indirect method, the impression of simple surface cavities may be taken in the same manner as previously described, or, in cases where the gum tissue may obscure a margin, the impression may be taken with a piece of sheet metal shaped to cover the cavity margins, which will act as a conveyor for the compound and permit the application of even pressure to all surfaces.

For cavities at the gingival margin (Fig. 99, *A1*), the modeling compound first is warmed on the end of the metal (*A2*), and then, holding it at an angle to pass under the gum margin and pressing back the overhanging soft tissue (*A3*), the compound is brought down to the surface of the tooth (*A4*), and held firmly in place. It is then chilled thoroughly and removed. This secures an impression which will show a clear outline of all surfaces and margins, unobscured by gum tissue.

Posterior gingival margin cavities may be secured in the same way, shaping a piece of sheet metal to cover the surface of the tooth so as to convey the compound to the subgingival margin.



A. *B.*

Fig. 99.

Die and Matrix Method, Impressions—Compound.—For corner restorations in anteriors (Fig. 100, *A1*), the impression should be taken in a tube, which may be shaped to cover the surfaces of the tooth beyond the cavity margins. The end of the tube should be trimmed so that, when put in place, the tube will convey the modeling compound to the deeper margins and confine it to the surfaces just beyond the cavity, thus excluding the contact teeth and surfaces which would otherwise form an undercut to the cavity outlines (*A2*).

Impressions of two-surface cavities in restorations (*A3*), and also mesioclusodistal cavities may be taken in the same way. The tube should be so shaped that it will extend beyond the gingival margin and pass slightly under the free gum margin, so as to exclude the soft tissue (*A4*). In taking the impression, the tube should be filled with modeling compound, warmed thoroughly and pressed into place, and held steady until chilled.

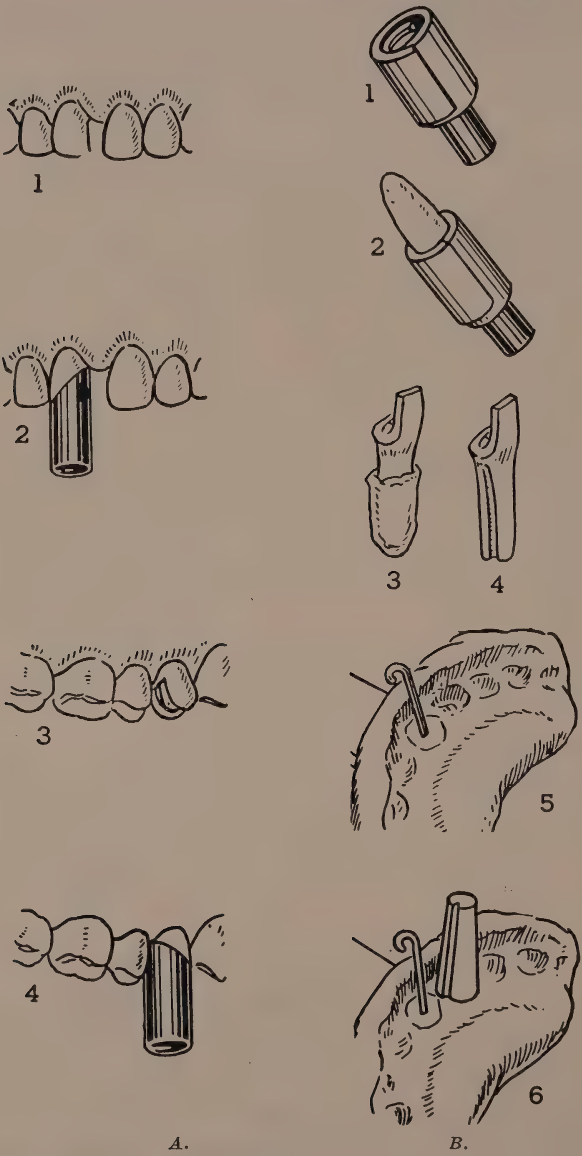


Fig. 100.

In all contour cases, a general impression should be taken similar to the impression for jacket crown technic, that is, a piece of casting wax is molded about the cavity and a plaster impression taken over it. When the occlusion is involved, a bite should be taken also.

Anterior corner restoration cavities should be prepared with square-cut labial margins, parallel to the long axis of the tooth. The lingual surface should be extended 50 per cent more than the labial, dividing between the enamel plates at the incisal edge. This will provide a square-cut step in back of the labial plate, extending to a slight pit in the gingival floor for retention. The cavity must draw incisally.

Posterior two-surface cavities should have square-cut walls and margins without bevel. Long, narrow sulci extensions should be avoided. Prepare the cavity so that occlusal surface margins do not fall directly upon an occluding cusp.

With the present-day perfection of jacket crown technic, large inlays that involve angles are becoming less popular. In preparing an anterior corner restoration with sufficient retention, there is often a greater sacrifice of vital tooth structure and a more dangerous approach to the pulp than would be required in preparing the tooth for a porcelain jacket. Furthermore, the jacket is a stronger and more serviceable restoration.

Amalgam Die Construction, Simple Impressions.—In making amalgam dies for simple surface cavities, the impression should be re-enforced for packing. A split rubber ring is filled with plaster and, as the plaster reaches its initial set (Fig. 99, *B1*), the impression is pressed into it, so that the plaster will form a wall around the outer edges of the impression material (*B2*).

As some plaster generates heat when setting, it is advisable to immerse it in cold water as soon as the plaster is hard enough to handle, in order to prevent possible distortion of the impression. The amalgam should be well triturated to a very smooth mix, and at first packed very carefully, in small pieces, into all margins. Then, after adding more amalgam from which some of the excess mercury has been expressed, fill until level and force out the excess mercury (*B3*). If the amalgam is packed on a vibrator, it will be easier to reach into all margins, and will bring excess mercury to the surface, insuring a harder die.

When the amalgam has set, the plaster may be cut away and the die removed from the impression in hot water. Rough surfaces beyond the cavity margins should be dressed off with disks (*B4*), so as to leave the surface smooth for the application of platinum foil and to make the cavity easily accessible for porcelain carving (*B5*). Metal dies, equal to amalgam dies in accuracy, may be made by plating and spraying methods. These require special apparatus, however, and the technic of the manufacturer of each type of machine should be followed in detail.

Poured metals and cements have been employed for making dies, but, in the writer's experience, none of these have proved equal to amalgam in accuracy and general satisfaction. In general practice it will be found that the use of amalgam dies will justify the additional time involved.

Amalgam Die Construction, Tube Impressions.—Tube impressions may be set in plaster in the same way as the simple impressions, or they may be wrapped with a strip of sheet baseplate wax, slightly warmed, so as to form a retaining wall into which the amalgam may be packed. Have the tube impression cold when applying the wax and chill immediately to avoid possible distortion of the impression.

Trim the wax so that there will be a wall about ¼ inch beyond the end of the impression, parallel to the tube (Fig. 100, *B1*). Pack soft amalgam into the deeper margins, and add small pieces of amalgam, from which the excess mercury has been removed. Condense the amalgam with a plastic instrument, taking precaution to avoid injury to the impression. Fill to the edge of the wax wall; then, with pressure and vibration, the free mercury can be expressed. Next, add a cone of amalgam beyond the retaining wall to increase the length of the die (*B2*).

When the amalgam has set, and after it has been removed from the impression, the rough surfaces may be ground (*B3*) so as to shape the die and permit its removal from the plaster model. A groove may be cut in one side of the die so that it will sit in a fixed position (*B4*).

The contact teeth of the general impression may be packed with amalgam, and a bent pin implanted in each tooth to hold it in the plaster model (*B*5). The die is placed carefully in the impression, then the model run in plaster, and articulated when the bite is involved (*B6*).

When the plaster model has set, the plaster may be cut away to expose the end of the die. The die may then be tapped out of the model to make the matrix and apply the porcelain.

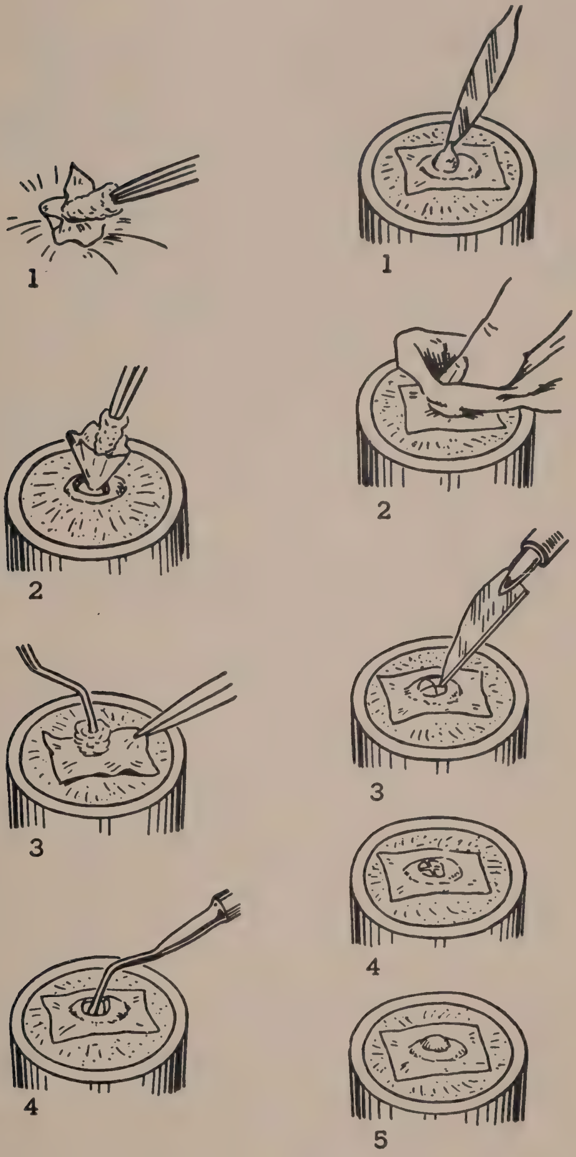
Simple Surface Cavities, Adaptation of the Matrix.—The amalgam die is set in the modeling compound in the swager base. Dead soft platinum foil, either 0.001 or 0.0005 inch, is adapted to reach down into the base of the cavity by pressing it into the palm of the hand so as to fold it loosely over a pledget of cotton, held with pointed tweezers (Fig. 101, *A1*).

This is then conveyed to the amalgam die, the foil being pressed into the deepest part of the cavity (*A2*), then the cotton forced down into the cavity with a burnisher until the foil is well seated on the entire base of the cavity. Hold this pressure firmly, and spread out the overlapping platinum foil with the tweezers to remove the folds and wrinkles as much as possible (*A3*); then swage, leaving the cotton in the matrix.

The swager settles the foil snugly to the surfaces of the amalgam die, but it does not remove the folds and wrinkles in the foil. This must be done by burnishing. First burnish the foil into the floor of the cavity, smoothing out all the folds carefully. Then burnish the side walls of the cavity, taking care that sharp corners are clear of folds. Finally burnish over the margins to remove any irregularities in the overlapping platinum (*A4*).

It is always advisable to reswage after burnishing, so as to be sure that there is no distortion developed by the manipulation. The reswaging should be done without any cotton in place.

The choice of the thickness of foil is optional. If 0.005 inch foil is used, the material is more delicate and is easily damaged. The heavier foil is tougher, and may be burnished more vigorously without injury. Actually, the foil is reduced in thickness by the burnisher, especially on the margins, and it is doubtful if there is a microscopic difference between two inlays made with either foil.



A. *B.*

Fig. 101.

The heavier foil may leave a slightly heavier cement space for the inlay, but the margins will be approximately the same. If thinner foil is to be used, it may be necessary to mount the matrix on investment. The burnished matrix may be filled with sticky wax to remove it from the amalgam die without distortion, and it may be mounted on a mound of high-heat inlay investment material. In the majority of cases, the heavier foil may be safely handled without investing.

Simple Surface Cavities, Application of Porcelain.—Porcelain powder is mixed with distilled water to a creamy consistency, and conveyed to the matrix with a carver (Fig. 101, *B1*). Then the porcelain is pressed into the cavity with a dry cloth over the finger tip (*B2*). This absorbs the excess moisture and condenses the powder at the same time. Fill to the level of contour, and take care that the porcelain does not overlap any margins.

With a thin blade, which may be made by shaping a safety razor blade to a point, score the porcelain right through to the matrix in two or more directions (*B3*). The object of scoring is based on a known characteristic of porcelain to shrink in fusing toward the center of its greatest bulk. If left in one piece, it will shrink toward the center, pulling away from the margins. When divided into segments, it will shrink away from the center, toward the margins, leaving wide crevices which are easily filled in following bakes (*B4*).

By inserting a blade under the edge of the foil, the matrix may be lifted from the die, then placed on a fire-clay slab and baked to a temperature 100 degrees below the glazing point.

Replace the matrix on the die, and add porcelain, pressing it into place as before. Build to a slight overcontour, but do not score the porcelain. Bake at 50 degrees below the glazing point (*B5*).

Practically all shrinkage has now taken place, and the porcelain inlay will have a semiglazed appearance, filled to the margins. The inlay now needs but little added porcelain to complete. The third bake is more of a ''retouching'' bake for correcting surface deficiencies of the second bake. Add porcelain to produce final surface character, and then fuse to the full glazing point.

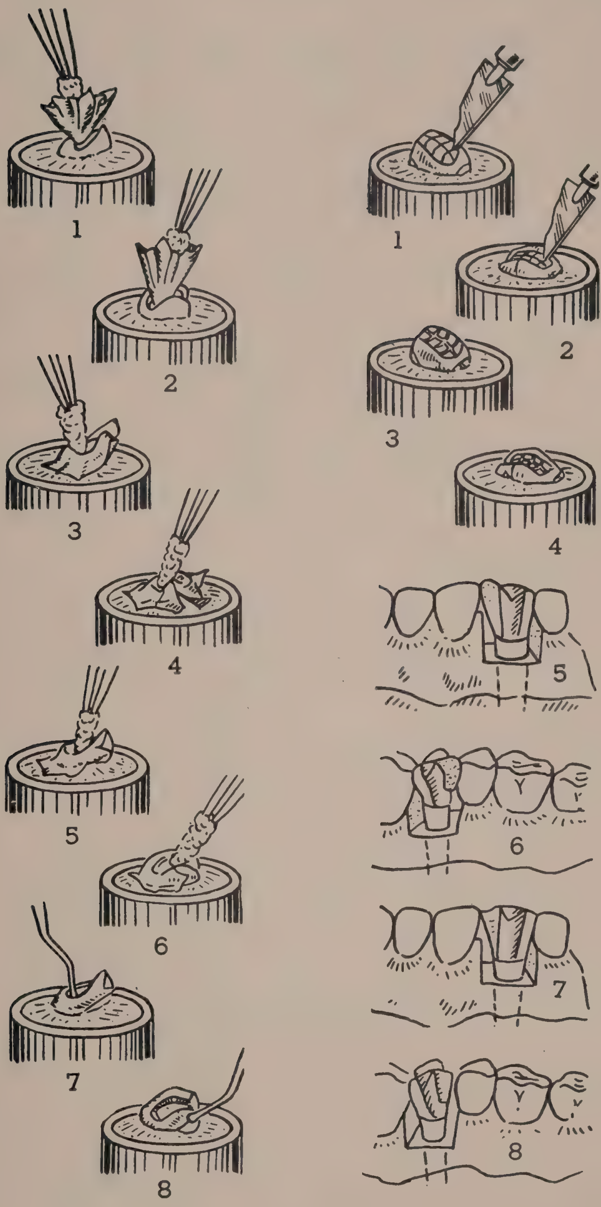
If the foil is loosened from all margins first, it will seldom tear or need to be ground off when removing the matrix.

There will be no overhanging margins if the porcelain is carefully carved, but if ''feather-edges'' show, they may be removed with an Arkansas stone held parallel to the margin.

Compound Cavities—Contour Inlays, Adaptation of Matrix.—For contour inlays, after the model is poured, the die is removed from the model and set in the swager base. Take care to align the depth of the cavity in the direction of the force of the swager.

The matrix is folded to reach the deepest part of the cavity and conveyed to place with wet cotton on the end of tweezers (Fig. 102, *A1* and *2*). Pack the cotton to carry the foil into the entire cavity, and then unfold the overlapping foil to cover the surfaces of the die while holding the cotton firmly in place.

Bring the excess foil together beyond the incisal edge of the anteriors (*A3*) or over the buccal and lingual cusps of posteriors (*A4*). This overlay is then



A. *B.*

Fig. 102.

folded smoothly over the labial surface (5) or the buccal and lingual surfaces (6), so that the foil will be as smooth and free from wrinkles as possible before swaging.

Swage firmly to place, leaving the cotton in the cavity, and then burnish the cavity depth, margins, and overlapping foil. Take care that the folds and wrinkles are thoroughly burnished out of the sharp corners and on the margins.

After burnishing, reswage and remove the matrix from the die with sticky wax. Trim the overlap so that the matrix will rest evenly on a slab, and then replace it on the die. If there has been any possible distortion in trimming, reswage and remove again.

With proper care, there will be few, if any, cut or torn places in the matrix. If a margin is torn, it is better to get a new matrix, but a small hole in the interior of the cavity will not do any harm.

In making contour inlays, the first bake of porcelain is applied while the amalgam die is in the swager base. Press the porcelain into the cavity with a dry cloth, and build the porcelain out to all margins.

Compound Cavities—Contour Inlays, Application of Porcelain.—Make no attempt at contour. Score the porcelain with a sharp blade to divide it into several segments (Fig. 102, *B1* and *2*). Then bake at a temperature 100 degrees below the glazing point.

The semifused porcelain will show shrinkage of the segments, spreading out the grooves cut by the blade but fusing to all of the margins (*B3* and *4*). Replace the matrix on the die and burnish over the margins to correct any possible distortions. Then remove the amalgam die from the swager base, and replace it in the plaster model.

When adding the second bake of porcelain, fill in the crevices, and build the porcelain to a slight overcontour. Carve the contact surface out to the line angle of the adjacent tooth on the model (*B5* and *6*). Pack the porcelain in place with a carver, absorbing the excess moisture with a dry cloth.

Remove the die from the model and add porcelain to the contact surface, building out to normal tooth form where the contact tooth has left a concave depression. This establishes a definite amount of overcontour which will compensate for the shrinkage of the porcelain to a very close degree. Bake at a temperature 50 degrees below the glazing point.

Replace the matrix on the die and add porcelain again. This time the overcontour should be very slight, merely retouching deficiencies in the second bake (*B7* and *8*). After becoming certain of the technic, the third bake may be brought to the final glazing point. Until the technic is certain, however, it is advisable to fuse just a little below the glazing point. Replace the inlay on the model, and either grind down, or add porcelain, if necessary. Then place in the furnace for the final glaze.

As Used in Matrix Technic.—In swaging matrices for inlays and jacket crowns, a plunger type of swager may be used but it should be constructed so that the plunger does not approach too close to the base, as the swaging material becomes depressed or lost in use. Some types of water swagers are efficient though not as quick-acting or convenient.

A good swager may be made of two pieces of heavy brass tubing, selected of different diameters so as to fit fairly close, one within the other. The exact measurements are not critical. The base may be 1-inch outer diameter tubing cut about 1 inch in length. The swager tube should have at least $\frac{1}{32}$ inch larger inside diameter, and be about 3 inches in length.

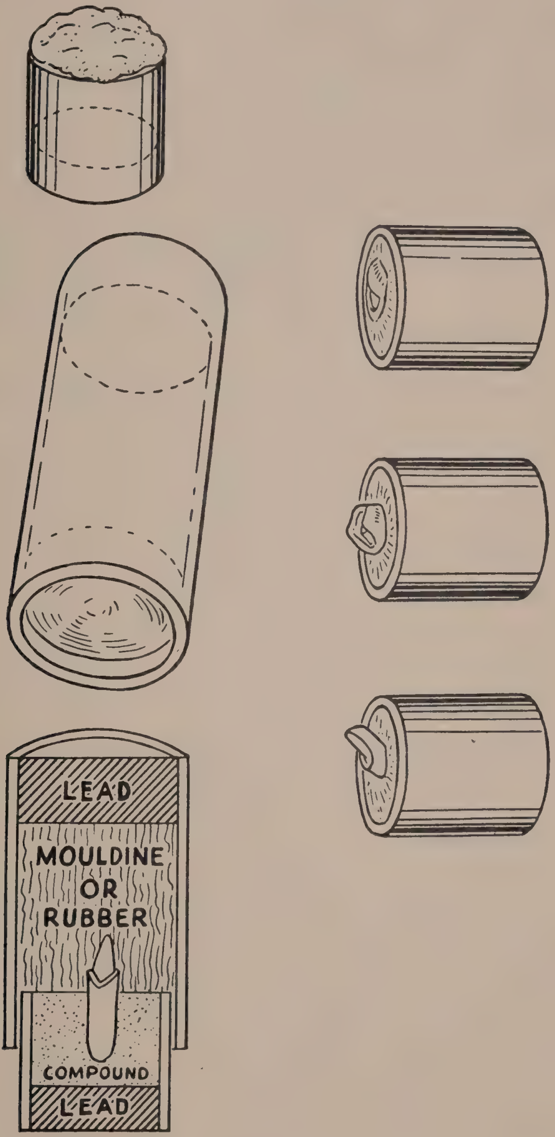


Fig. 103.

Each piece of tubing is to be filled one-third of its length with melted lead. The base is to be filled with modeling compound which acts as a support for the amalgam dies. The swager may be filled within ½ inch of the end with moldine or putty, over which a sheet of rubber dam is placed, if the swager is to be used with a hammer. (Fig. 103.)

If a hydraulic or screw press is to be used, a better swaging medium may be constructed by cutting about 1½ inches from a half-yard roll of medium rubber dam. This cylinder of rolled rubber will fit into the swager, making an ideal, adaptable, elastic swaging medium.

Impressions, Dies and Models.—The impression data for porcelain jacket crown construction consist of a ''tube'' impression, a general impression, and a bite. The impression tube should be fitted to pass over the periphery of the tooth and under the gum margin, then filled with modeling compound and pressed firmly to place, thoroughly chilled and removed.

For the general or ''contour'' impression, a piece of casting wax is molded over the prepared tooth. It is left bulky on labial and lingual surfaces, and a plaster impression is taken over this casting wax core. Caution should be used to be certain that the wax core is firmly in place, and not dislodged, when applying the plaster. Also guard against the plaster's heating and distorting the wax.

An ordinary wax bite will answer most requirements, but greater accuracy may be assured by taking an impression of the occluding teeth, then making a separate sheet wax bite for adjustment of the two models.

The tube impression may be wrapped with sheet wax so that the amalgam can be packed under pressure and vibration to insure a perfect model. Note that the impression tube is not always parallel to the impression, and consequently the wax wrapping should be shaped to follow the center line of the impression, rather than merely following the surface of the tube (Figs. 104, *A1* and *2*).

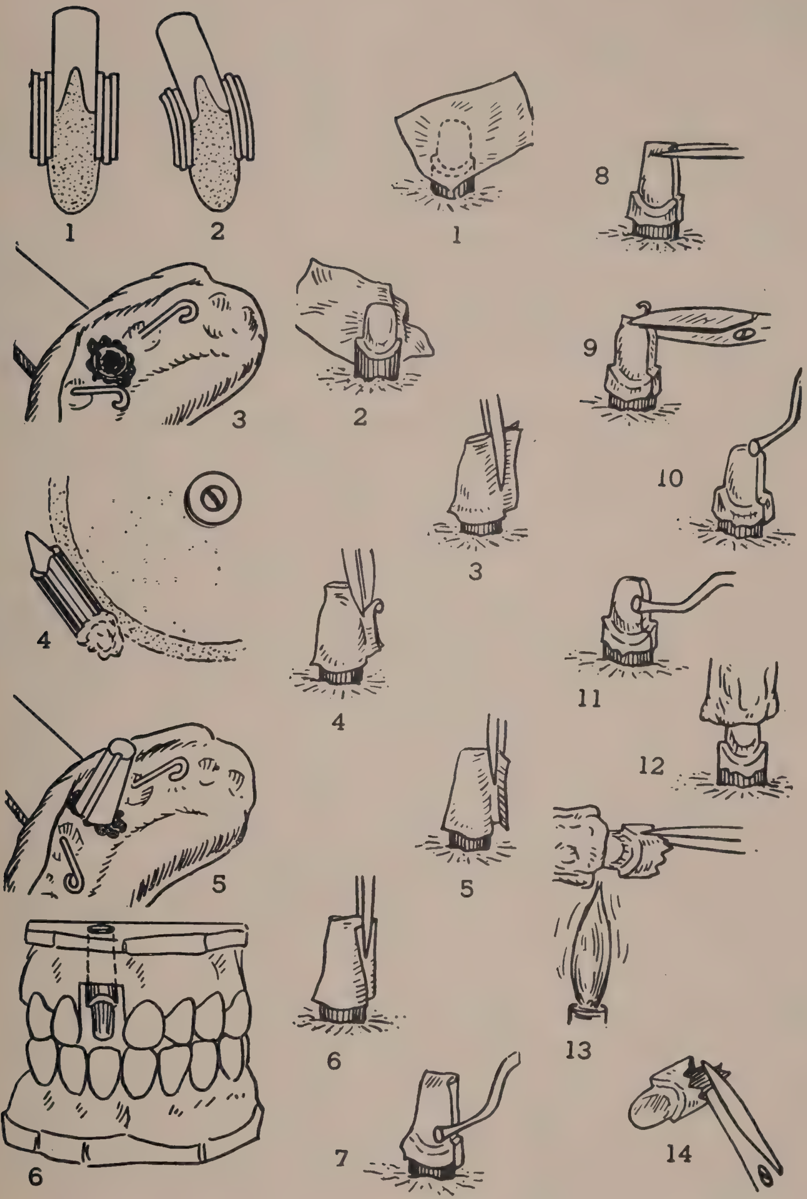
Pack well-mixed alloy into the impression in small pieces under vibration and pressure, squeezing out the excess mercury and adding a tapering cone beyond the wax wrapping, so that the die will be at least 1 inch in total length.

The contact teeth in the general impression should be packed with amalgam, and a bent pin should be implanted in each tooth to hold it in the plaster model (*A3*).

When the amalgam has set, remove it from the tube impression and grind off the excess material. Shape the die so that it will be straight in line with the margin for at least ¼ inch and then taper slightly. Rough shaping may be done with a coarse lathe stone (*A4*), then finished with a paper disk and polished so that it will slip easily from the plaster model. The die is then seated accurately in the general impression and the model poured (*A5*). When set, the die may be removed from the model, and the rough edges of plaster about the margins may be trimmed away to allow free access for the matrix (*A6*).

Matrix Construction.—The amalgam die is mounted on the swager base, and carefully centered, so as to have an even distribution of pressure when swaging.

Dead soft platinum foil, 0.001 inch in thickness, is cut to a rhomboid shape, judging the size by the length of the die. The right angle is placed over the



A. *B.*

Fig. 104.

labial surface (Fig. 104, *B1*), and the long surface wrapped around the lingual surface of the die (*B2*) so as to meet the shorter surface at the lingual line angle of the die.

Draw the foil snugly to the surface of the die with pointed tweezers (*B3*). The loose edges may then be trimmed to an even length of about one millimeter beyond the surface of the die (*B4*). Then, dividing this length in half, crease it and fold the two edges together (*B5*), and draw the foil snugly around the die. Then lay this folded edge against the surface of the die (*B6*), and burnish it lightly into the shoulder (*B7*).

Large bicuspid matrices are made best with two "tinner's joints," choosing distobuccal and mesiolingual line angles as locations. Molars may be made with four joints, one at each of the line angles. This will produce a matrix with a single thickness of foil over the occlusal surface. In selecting the line angles for the joints, the location where the porcelain may be contoured the most heavily is chosen.

Soft platinum is ductile and it compresses under heavy burnishing, so that the actual thickness of the joint is but little heavier than the single thickness of foil throughout the remainder of the matrix.

By the use of proper care in laying the foil on the surfaces of the die, and by choosing the location for the double fold or "tinner's joint" where the shoulder is well defined and smooth, it will be possible to make the matrix fit snugly, and it will be practically free of folds or wrinkles before swaging.

Draw the edges of the foil snugly to the incisal edge with tweezers (*B8*), and then trim off the excess as closely as the scissors will cut (*B9*). Fold the free edges toward the lingual, and burnish down lightly (*B10*).

The matrix is then ready for swaging. The swager will set the foil snugly over all surfaces, but there will be some folds which must be burnished out. Beginning at the incisal edge, burnish the folded edges downward, following each fold or wrinkle down to the shoulder. Burnish *hard* over the "tinner's joint" where the ends of the foil were folded together (*B11*).

The shoulder is then burnished while applying firm pressure where the joint crosses the margin, until the extra thickness is reduced so that it is undetectable. Finally burnish over the periphery of the margins and over the "apron" beyond.

The swager drives the foil down into all surface irregularities of the die, and it is often difficult to remove the matrix. It should first be removed from the die by heating a piece of sticky wax and pressing it over the surface of the matrix (*B12*). Then remove the matrix from the wax over a flame (*B13*), and burn off the residue of wax. Select a stick wax which will burn off clean.

The edges of the foil may then be trimmed evenly, so that the matrix will sit level upon the fire-clay slab (*B14*). Replace the matrix on the die, reswage and remove as before, then carefully replace it on the die once more, and it is ready for the application of the porcelain.

Application of Porcelain.—There are two schools to follow in the application of porcelain for jacket crown work. One method is to carve the porcelain to full contour on the first bake, either varnishing the margins of the platinum matrix to allow the porcelain to draw away from it, or "ditching" the porcelain at the margins.

The other method is to make a foundation bake of porcelain to fill in at the shoulder and fit the margins. Then the contouring is done in the second bake. Either method will produce equally good results.

In the writer's experience, the former method is less precise and takes more time, with a greater likelihood of requiring extra bakes to fill in the deficiencies at the margins. In the latter method, only a little time is consumed in the primary bake, and the restoration may usually be finished in one final carving. It is the latter method which is described in the following paragraphs.

The amalgam die, set in the swager base with the finished matrix in place, is most convenient for the application of the first bake of porcelain (Fig. 105, *1*). The porcelain is applied quite wet with a carver, and conveyed into the shoulder flush with the margins, so as to cover the "core" with a very thin layer of porcelain. A dry cloth is used to absorb the excess moisture (*2*), and to pack the moist porcelain down into the shoulder.

Then the carver is employed with a burnishing stroke to further pack down the porcelain and to remove the excess material (*3*). Use a downward stroke, always working toward the margins. The final smoothing of the porcelain may be done with a cloth over the finger, brushing to the margins and cleaning the porcelain powder off the "apron" beyond the margins (*4*).

The matrix is now removed and baked to a temperature 100 degrees below the glazing point. If the porcelain has been properly packed and not disturbed in handling (*5*), the baked porcelain, although showing some shrinkage but not pulling away from the margins, will cover the matrix (*6*).

If an opaque porcelain base is desired, then the opaque porcelain is applied over the "core" of the matrix down to the shoulder, but not to the peripheral margin. This opaque porcelain is applied sparingly with a brush, choosing a color which approximates the color of the porcelain to be applied over it. It is baked at 100 degrees below the glazing point, and the first bake of porcelain is applied over it as described above.

In accordance with the known characteristic of porcelain to shrink toward the center of *greatest bulk,* this critical center is established at the shoulder, so that the direction of shrinkage will be toward this area (*7*). Otherwise, if the bulk of the crown were put on at the first bake, the direction of the shrinkage would be away from the shoulder. This would result in the porcelain pulling away from the margins and possibly distorting the matrix (*8*).

In unusual cases, where the tooth has been broken down and the preparation shows a wide shoulder on one side (*9*), or in cases where the core is extremely small with a wide shoulder, as, for example, where a jacket is made over a root in which a Davis crown pin has been cemented, the first bake of the porcelain should be scored with a sharp blade (*10*).

When this is done, the porcelain will shrink in segments and fuse to the margins. The fine lines cut with the razor blade will open into wide crevices, into which porcelain may be easily applied so as to build it again to the same form as the normal first foundation bake. This method is also employed in making molars and large bicuspids, and two bakes are taken to set the foundation porcelain (*11, 12,* and *13*).

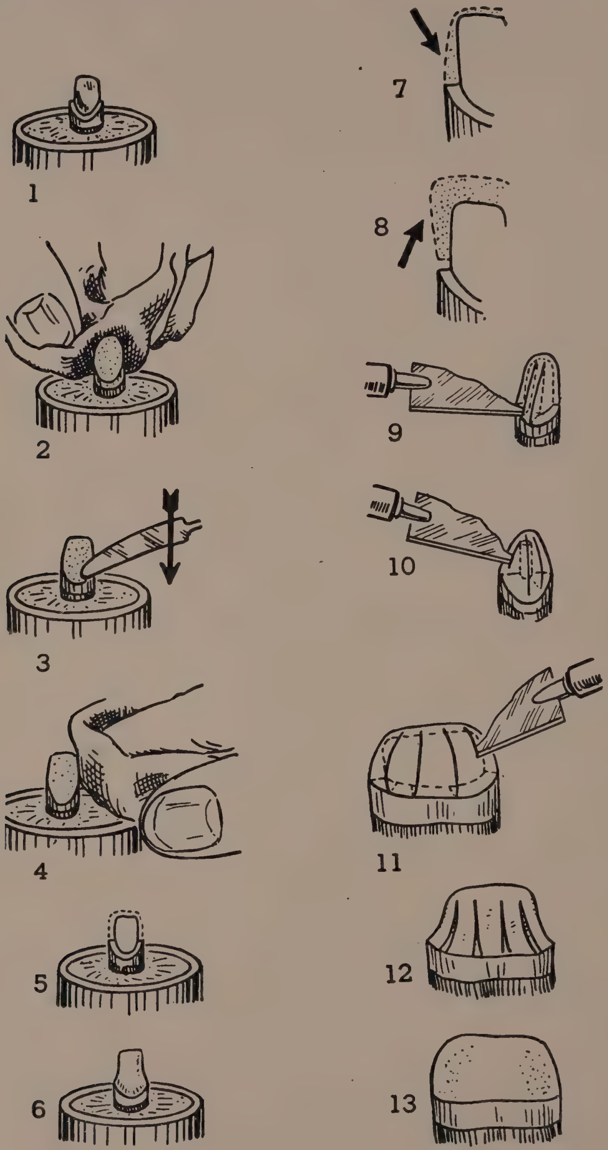
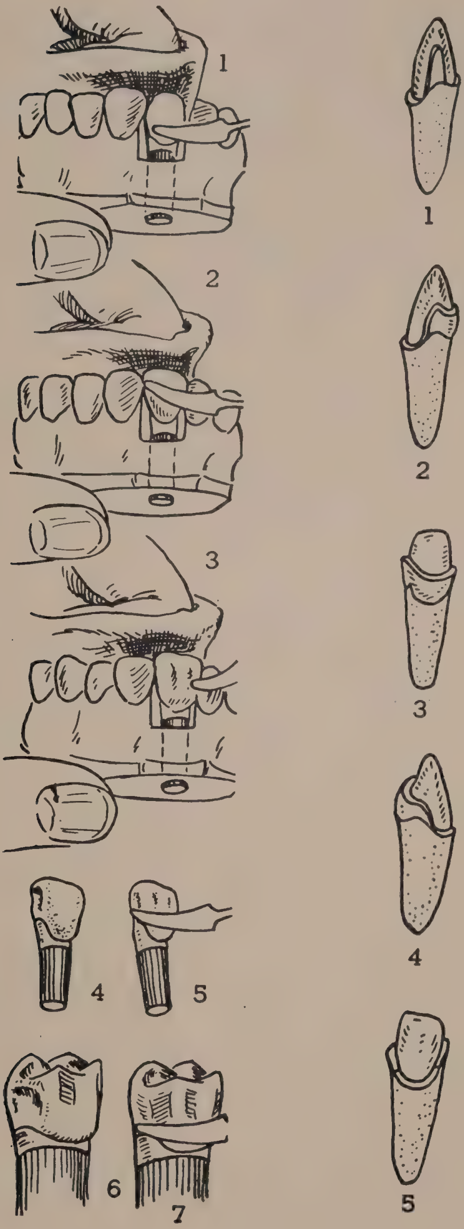


Fig. 105.

With the foundation porcelain evenly baked to the margins, the second known characteristic of porcelain is that the added porcelain will shrink in the direction of the *first bake.* This explains why the porcelain may pull away from the margin a second and a third time, if the bulk of the porcelain has been applied at the first bake and the direction of shrinkage established away from the margins.



A. *B.*

Fig. 106.

The opaque base in a porcelain jacket crown, which has been promoted under various trade names in some laboratories, neither adds to nor detracts from the strength of the restoration. Its function is to act as a color shield against underlying tooth structure, which may be discolored or restored with metal. With normal preparation on a vital tooth, the opaque base is but an additional, unnecessary step in technic with but little justification.

Porcelain Carving.—The die is now placed in the model. The gingival color is applied first, and the porcelain built out to full gingival contour. The color is carried to the desired point, and then tapered off toward the incisal edge (Fig. 106, *A1*). The porcelain is applied wet and the excess moisture absorbed with a cloth. Then the porcelain is molded to form with a burnishing stroke of the carver toward the gingival margin. The incisal porcelain is now added, and extended over a portion of the gingival porcelain to blend the colors.

The cloth is held on the lingual surface when the wet porcelain is applied on the labial, thus keeping the right degree of moisture in balance (*A2*). When carving the lingual surface, the cloth absorbs the moisture through the porcelain which has been built on the labial surface. All necessary condensation is effected through burnishing and the absorption of moisture. The porcelain is thus held under control and the colors are not confused as is usually done when vibration methods are used.

The incisal length may be built one-sixth longer than normal length of the crown. The proximal surfaces are built to the line angle of the adjacent teeth on the model. The gingival ridges should be exaggerated, but practically no visible overcontour should be made on the labial or lingual surfaces. Developmental grooves and ridges should be slightly exaggerated (*A3*).

The die now may be removed from the model and porcelain added at the proximal where contact surfaces of the model have left grooves (*A4*). These surfaces are built out to the normal tooth form (*A5*).

The average index of shrinkage is from 15 to 20 per cent, depending upon manipulation, but there are no definite mathematics whereby a linear measurement may be calculated for a solid as irregularly formed as a tooth and with a core as irregularly shaped as the average preparation. This rule of overcontour, by building to the adjacent line angles and filling the depressions thus established, is very nearly precise. It is equally adaptable to small incisors or large molars (*A6*).

In posterior carving, it is necessary to close the articulator to full contact in order to establish the occlusal planes. Cut sulci deeper, and add overcontour to the cusps and contacts only (*A7*).

The skilled operator may now bake the crown to the full glazing point but, until the technic is certain, it is advisable to fuse the porcelain 25 degrees below the full glazing point, then replace it on the model and either grind off or add porcelain where necessary. Return it to the furnace for the final glaze at the full gazing point of the porcelain.

Various methods of condensation of porcelain have been in common practice, such as vibrating, beading, moisture absorption through dehydrated molds, and others. For each one, claims are made of insuring a more dense finished product. The fact is that, aside from the amount of shrinkage of the porcelain in baking, there is no real difference in the completed porcelain restoration, regardless of which method of laying the porcelain may be followed.

In a recent test, a steel mold was used to make cylinders of porcelain of uniform size. One was loosely packed; the second had the porcelain vibrated into it, and the third had the porcelain packed under hydraulic pressure. The three cylinders were baked at the same time. The first showed considerable shrinkage; the second, less shrinkage; and the third, very little. But the three pieces of porcelain were identical microscopically, in specific gravity, and in physical property tests.

Vibrating porcelain in a ceramic mold or investment model will condense the porcelain and reduce the shrinkage, but in a platinum matrix there is not enough gained to compensate for mixing up the colors and running over the margins.

Bubbles and porosity in porcelain are not due to manipulation but rather to the introduction of dust, fumes, or foreign matter, which may be gaseous at the fusing point of the porcelain, or react upon the fine chemical balance of the porcelain formula.

Jacket crown carving cannot be covered in a limited technical treatise, such as this. Aside from a few rules for overcontour and the consideration that the furnace tends to level off sharp points or ridges and to fill up grooves, porcelain carving is an *art* rather than a technic. It consists of a knowledge of dental anatomy as well as skill in carving and in keeping the porcelain to the right degree of moist consistency. All this can be attained only through long practice.

Methods of Construction.—A correctly designed thimble is very serviceable, but unless the gold foundation is properly prepared, the porcelain jacket will be weakened.

Too often the casting is but a "thimble," as its name suggests, with a sharp angle on the side to which the bridgework is soldered. The full stress of the bridge is exerted against the thin shell of gold under the porcelain. Gold will eventually "spring" and cause the porcelain to chip and come off. Even assuming that the gold casting may be rigid, the sharp wedge of the casting has built a line of cleavage into the porcelain as though a glass cutter had been used to mark the place for the crown to break under its first stress.

The incorrect type of construction, commonly adopted for thimble crowns, is here shown (Fig. 106, *B1*).

The proper form of construction for the practical thimble crown is indicated by *B2, 3, 4,* and *5.* Note that the shoulder in each case is designed in the casting, so as to start at the proximal line angles and continue in a curve.

The shoulder should be designed to provide sufficient solder surface where needed but not to show any abrupt steps. This insures a design in which the casting extends as part of the exposed shoulder two-thirds around the tooth. It is practically a clasp with ample strength, so that it does not depend upon the thin "thimble" for rigidity.

When the porcelain jacket is cemented on such a casting, it will have no weak spots, and will completely conceal the gold on the labial surface. Thimble crowns constructed in this fashion are very serviceable abutments for bridges.

The same general principle may be followed in cases where a nonvital tooth is to be used as a bridge abutment. The casting is made to extend into the canal and is designed to restore the core and shoulder as illustrated, leaving the labial shoulder on the tooth structure.

In cases of fragile teeth, the casting may be constructed as a band to give the root additional support and still be so designed that there will be no visible metal on the labial surface.

Shade Selection.—Color selection has always been a major problem in porcelain restorations. To match the blends of shades in the mouth with block colors of porcelain, and to attempt to estimate the proportions which will combine to produce intermediate blends requires a perception of color values attained by but few operators. Most operators are skilled in matching the natural teeth to an artificial tooth shade-guide, as the blended shades of porcelain more closely approach the natural blends of the tooth.

The selection of shades may include parts of more than one shade-guide specimen, since the gingival portion of one shade and the incisal of another may be needed to match the natural tooth. The correct selection of block shades of porcelain may be made at the workbench to match the selected shade-guides, uninfluenced by the shadows in the mouth.

Formulas may be made to match the artificial tooth shade-guides with the shades of porcelain, corrected by trial and error, until the operator has a complete chart of formulas to match his favorite guide with his favorite porcelain. Some porcelains are supplied with formulas to match all shades of the four popular artificial tooth shade-guides.

No chart, however, will produce blended shades without some judgment being used on the part of the operator. Shades of different manufacturers differ in the relative proportion of gingival and incisal shades. For example, one shows but little gingival shade with the incisal color extending beyond the middle third, while another shows the gingival shade covering more than two-thirds of the tooth. Often neither guide will match the actual color blend of the natural tooth, in which the gingival color may extend incisally throughout the central portion of the tooth and the incisal color may extend beyond the gingival third on both mesial and distal angles.

In laying the first bake of porcelain, the gingival color is used to cover the entire matrix. In the contour bake, the gingival color is applied first, and it is built up a little beyond the section of the crown selected for this color. The incisal shade is then applied over a portion of the gingival color, so that the two shades will blend, but will not show a sharp line of demarcation between the colors.

Shadow translucency of thin incisal edges is best simulated with stains, either applied to a subsurface of the porcelain when baking and a final surface of porcelain carved over it, or to the finished crown. Line checks and surface stains are often required to match natural conditions, but the operator is cautioned against overdecoration. Removal of the glaze of the jacket on the proximal and incisal edges will cause the crown to accumulate smoker's stain more naturally than can be applied with colors.

A Discussion.—It has been previously stated that various methods of manipulation and condensing porcelain have little or no effect upon the physical properties of the finished product. That does not hold, however, when it comes to fusing porcelain.

In the ceramic industry, dental porcelains are not classed as true porcelain, but are classified as "porcelain glaze." True porcelain does not glaze, and, consequently, a glaze must be added to the finished product. Porcelain is not a vitreous substance but, under the microscope, it appears greatly like concrete, as a mass of crystals bound together with a binder, its strength depending upon the relations of the crystals.

To secure the depth of translucency needed to simulate natural teeth, dental porcelain is made with glazing qualities. It is strongest when slightly underglazed. Esthetics demands a glazed surface, and so, to have the strongest material combined with the best appearance, a dental porcelain restoration should be fused at a definite temperature within a certain time, which will produce a glazed surface without "overcuring" or without extending the glaze too deeply.

The thermochemical action which "cures" porcelain is progressive. It will be noted that in "Reinforced Porcelain Bridge Technic," each successive step was carried to a higher temperature. Also, it may be noted that the fusing point was not mentioned. That is because a restoration of this type must be heated slowly and allowed to cool slowly, otherwise the heat-conducting heavy metal will expand or contract more rapidly than the nonconducting porcelain, resulting in a strain or fracture.

As the time element is increased, the temperature required for fusing porcelain is decreased. Thus, porcelain which glazes correctly at 1875° F. when brought to that temperature from a cool muffle in fifteen minutes, will be cured at 100 degrees below that temperature when the time is extended to forty-five minutes and then allowed to cool in the furnace, as is advisable with bridgework. A pyrometer test by melting pure gold will check the accuracy of the instrument, but a furnace test is best made by fusing porcelain and noting the time and the temperature required to produce correct glazing.

In concluding this treatise, it may be said that there is no conclusion. Porcelain work has reached a point of practical perfection, and yet there is still room for improvement. Development and research are constantly bringing forth important refinements in technic. Ceramics is one of the oldest arts of man, and yet it is one about which science has much to learn.

Dental ceramics is the latest art in the practice of dentistry, and it has contributed in the highest degree to the esthetics of dental restorations, but Art is never finished.

Repair of Fractured Jacket Crowns.—In the setting or subsequent use, the jackets are not infrequently fractured, sometimes to the extent of loss of a large part of the lingual wall.

The repair of this is quite an easy matter. With major portion of the crown in position, take a small and accurate impression of the surface of the crown needing repair. Remove the crown, place the same in the impression, and pour up a model of the tooth peg with Ransom and Randolph's porcelain investment compound and proceed to fuse to the crown a new restoration after the technic of making a fused porcelain inlay without matrix.

The finished product should show no line of repair and fit the tooth peg even better than did the original, as no doubt the fracture was due to slight misfit.

Broken pieces of porcelain teeth and facings may be successfully repaired in much the same manner.

A Suggestion.—Students as well as busy practitioners interested in fused porcelain in dentistry will do well to follow out the line of technic given for practice work as they will find the methods timesaving and most accurate as to final results.

Those who have done so have found it a pleasant field and a most efficient practice builder.

CHAPTER XXX

CAVITY PREPARATION FOR GOLD INLAYS

Definition.—An inlay is a body placed within a previously prepared excavation. As applied to the filling of teeth it refers to the process whereby the filling is inserted into the cavity of a tooth in one piece and retained there by the assistance of cement.

The materials in most common use are porcelain, pure gold and alloys of gold, and alloys of base metals.

The Indications for a Gold Inlay.—First, in large contour restorations, as there is a material saving of both time and energy on the part of both patient and operator. Such cases, particularly with posterior teeth, are frequently crowned with the shell gold crown with its almost universally irritating band, when the inlay could be of greater service.

Second, when it is difficult to maintain dry conditions for a long period of time about a cavity, as with large gingival cavities in molars and bicuspids.

Third, when there are extensive occluding surfaces to be restored. It is much easier to cast a correct contour than to build up with the plugger point, which is largely guesswork when the rubber dam is in position.

Fourth, when it is desired to put in a number of fillings in a given short time. In such cases the operator can make the wax models, and engage the help of the laboratory in completing the fillings while he is still busy with other fillings at the chair.

Fifth, when the necessary force to properly condense a cohesive gold filling is not permissible, as with loosened teeth or invalid patients.

Gold inlays are not indicated in small cavities, or shallow cavities unless the outline is extensive.

The cavity preparation for a gold inlay does not materially differ from that which has already been advised in the preceding chapters. It is possible to construct an inlay without change for nearly every cavity which has been correctly prepared to receive a cohesive gold filling. If the order of procedure is slightly rearranged, however, the operation is simplified.

This change in the order would be to put retention form last, attending to that part of the cavity preparation after the model has been made and just before setting the inlay.

In cases where this has not been done or the cavity is naturally retentive, the retention should be temporarily covered later as will be described while making the model.

Change of Position of Retention Angles.—It is quite ideal to cut just as heavy retention angles in the different classes of cavities for gold inlays, as for cohesive gold, only they should be laid in a different position and cut at the expense of the base walls rather than the surrounding walls, in order to give the cavity draw. This feature of the cavity preparation will be described as we consider the preparation of cavities by classes farther on in this chapter.

The order of procedure for inlays would then be as follows:

1. Gain access.
2. Outline form.
3. Resistance form.
4. Convenience form.
5. Removal of remaining decay.
6. Finishing enamel walls.
7. Toilet of cavity.
8. Retention form, which is given as the fourth order in other forms of fillings.

Gaining access for inlay filling is the same as that with other fillings as far as surgical procedure is concerned. No more tooth substance should be cut away on this account.

When using preliminary separation for access, there should be more room secured in most of Class Two or Class Three cavities, as this will materially assist in getting a correct wax pattern as well as aid in the process of placing the inlay.

Resistance form for inlays should receive the same careful consideration as given for other fillings. Weakened enamel walls should be protected not only from the subsequent force received in stress but from the stress of setting the inlay. Flat seats for all inlays are imperative. The usual steps in Classes Two and Four are called for as an important factor in retention to resist the tipping strain.

Convenience form for inlays should not be practiced to excess. No convenience points are required. The major portion of convenience form should be gained through separation, preferably slow separation.

Removal of remaining decay.—When it has been fully determined that the pulp is not to be removed, some decay may be left on the axial wall or in the region of the buccoaxial or the linguoaxial line angles, until the inlay has been cast and fitted. It should then be removed and the dentine overlying the pulp, if hypersensitive to thermal changes, given a coat of cavity varnish. Allowing this softened dentine to remain during the interim between the making of the pattern and the setting of the inlay will protect the pulp against irritation and save devitalization before setting the inlay.

The finishing of the enamel walls will necessarily come in at this point as all cutting of the external outline of the cavity must be completed before proceeding to make the pattern. The only change advisable is that the cavosurface angle should be more obtuse, and the bevel angle should not be as deeply buried, which results in a thinner metal edge.

This will assist in burnishing the margins to a closer adaptation in the final finish.

More beveling at the cavosurface angle should be resorted to for two reasons. First, the gold inlay should have a margin of rather an acute angle in order that the material may be burnished more closely to the margin. Second, during the process of setting the inlay and burnishing the margins, the cavosurface angle stands in great danger of being fractured.

The Toilet of the Cavity for Gold Inlays.—Herein lies the greatest weakness in inlay methods. No cavity margin is surgically clean after it has been moistened or been in contact with the inlay wax pattern.

After the pattern has been formed and removed, our mehods will not permit the planing of the cavity surfaces, particularly the margins, again, which is the only way to render them entirely clean.

Hence, just before setting the inlay, we are forced to wash the cavity walls with solvents of the substances which have contaminated them. Without going into detail, it is advised that the cavity be thoroughly scrubbed with chloroform, then absolute alcohol as a second cavity toilet, and immediately the cavity be flowed with the cement, introducing the inlay under dry conditions.

Line of Approach.—In inlay work the cavities should be approached from the direction in which they are to receive stress during service.

In withdrawing the wax pattern, and when the inlay is placed, each should travel parallel with a line drawn from the seat of the cavity to the source of the force of mastication. This line of approach is good practice with any filling but is more essential with the gold inlay than the cohesive gold filling, for we do not have the assistance of the elasticity of the dentine in retention, made possible by the use of the wedging principle in the manipulation of cohesive gold.

Preparation of Cavities of Class One

Of the cavities of this class calling for gold inlays, only the large occlusal surface cavities in molars are of importance. Small pit and fissure cavities are more quickly and easily filled by other methods.

Outline Form.—In large occlusal cavities the outline should be so carried as to avoid eminences at the crest of the marginal ridge. When this is reached on the buccal or lingual, the outline should include the marginal ridge, and at least one millimeter of the axial wall should be involved. All deep grooves should be included. The curves should be as generous as possible.

Resistance Form.—The same rules apply as to other fillings. When much of the supporting dentine has been removed through decay or cavity preparation from either the buccal or lingual walls, that portion within the cavity should be covered with a thin layer of black wax, which prevents the wax pattern from coming in contact with these walls. The cast inlay will then not touch these walls during the process of introduction, which will often save a fracture of these walls, due to stress from within when driving the inlay home to a seat.

The major portion of retention form comes in for consideration after the inlay has been cast and fitted and just before it is cemented to place. A flat seat and nearly parallel walls to this seat with fairly definite angles are necessary to guard against the tipping strain and produce proper retention form.

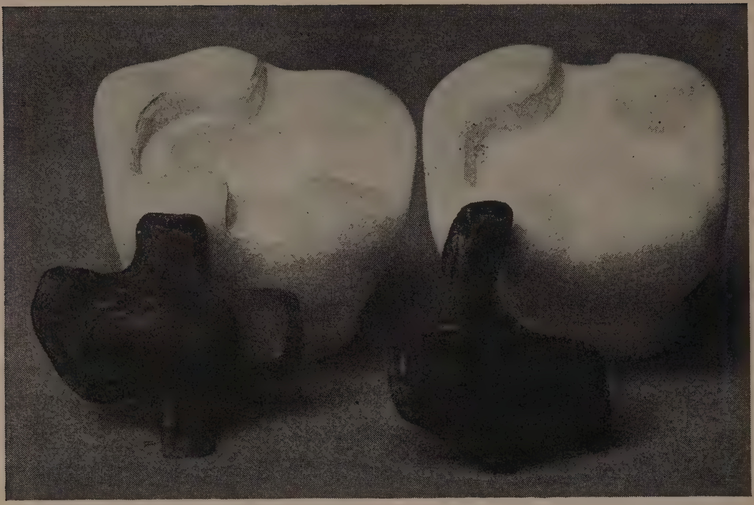


Fig. 107.—Cavities of Class One for gold inlays. Cavity side of inlays shown.

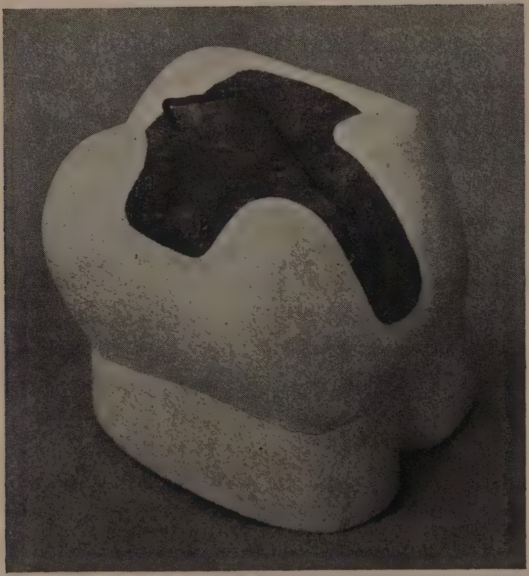


Fig. 108.—Class One inlay in position showing gold wire cast in the filling, which was put into the wax pattern to support the long buccal arm. Cavity shown in *B*, Fig. 107.

Preparation of Cavities of Class Two

Large proximal cavities in molars and bicuspids are successfully handled with this method of filling.

Access.—Preliminary separation is of the greatest service here and should be general practice, as much cutting for convenience form is avoided and better contact is secured.

Complete preliminary separation very materially facilitates the removal of the wax pattern as the operator does not have to be as careful about having his wax pattern tight against the surface of the adjacent tooth. In addition to the preliminary separation before making the pattern, it is to the advantage of the operator to pack the case for additional separation during the interim between making the pattern and setting the inlay.

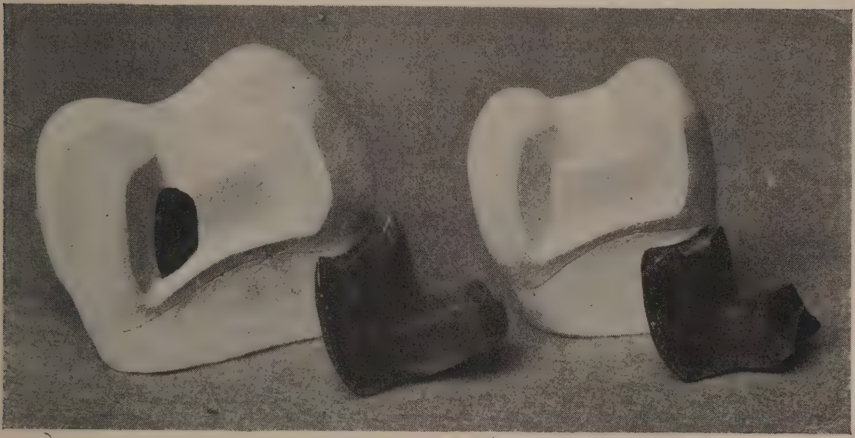


Fig. 109.—Cavities of Class Two for gold inlays. Cavity side of inlays shown. Black wax has been used in the molar to temporarily remove the retention produced by decay.

Outline Form.—The outline for inlay filling is much the same as for other methods. Care should be taken that the buccal and lingual walls are parallel, particularly the enamel portion of these walls, as the wax pattern must move directly to the occlusal surface in exit. It is equally essential in inlays that angles and sharp turns in outline be avoided, particularly as they will not take in the wax pattern and any defect in the casting exaggerates the misfit.

Resistance Form.—Flat gingival and pulpal walls are demanded in Class Two. Weakened buccal and lingual cusps should be removed and replaced with the filling material.

Retention form is best secured for vital cases by making four convenience angles in each case similar in size to those for cohesive gold. However, these convenience angles should be laid down in the gingival and pulpal walls and cut entirely at the expense of these walls rather than at the expense of the tooth substance in the region of the ascending line angles. To describe the process more accurately, take a round bur, about No. ½ or No. 2, sink it into the gingivoaxiobuccal and gingivoaxiolingual point angles about the depth of the bur. To this point the procedure is the same as though we were going to make a convenience angle for cohesive gold. Instead of sinking the bur laterally into the ascending line angle and drawing it occlusally, as with cohesive gold, we draw it toward the mesiodistal plane along the gingivoaxial line angle, allowing it to fade out, after going once or twice the width of the bur, taking the tooth substance from the gingival wall. Treat both lower point angles in this manner. In the step portion of the cavity follow the same procedure in the two point angles, cutting all tooth substances at the expense of the pulpal wall. This results in giving the cavity draw to the occlusal and giving the inlay four lugs, which key the filling to a seating, particularly in the region of the gingivobuccal and gingivolingual point angles. It also results in placing your retention form high in vital cases and near the force of mastication and in a part of a vital tooth which is well suited to stand the tipping strain. (Fig. 109.)

In pulpless cases the retention form should be placed low in the tooth. In fact, the major portion of it should be below the gingival wall, and this is more frequently secured by the use of the pin inlay. When the pin is not used, the pulp chamber is so shaped that the wax pattern will show a lug which can be used for the major portion of the retention.

Finishing of Enamel Walls.—This part of the cavity preparation should be attended to with all of the care and detail that is required when making a cohesive gold filling. In addition thereto, after the planing has been done with a chisel, particularly on the buccal and lingual outline, these margins should be polished with a very fine grit disk. This facilitates the travel of the wax on these two surfaces when going to exit. A chisel finish on these surfaces results in a pattern that, under the microscope, shows little fine projections which have gone into the roughened surface. In drawing the pattern these little projections have been bent, and point gingivally. This results in an imperfect casting along these surfaces and interferes with the fit, whereas, if the surfaces have been polished, a polished wax pattern results and the completed inlay more nearly fits the margins.

When the cavity, on account of decay, is naturally retentive or has undercuts, these are temporarily filled and overcome by covering the retentive portion of the cavity with some substance, as temporary stopping or wax of a different color from that used in making the pattern.

Preparation of Cavities of Class Three

The gold inlay is seldom indicated in cavities of Class Three. An exception may be made in those which are large and, through decay, have lost their entire lingual wall.

Access is of a necessity from the lingual, as Class Three cavities receive their stress from that direction.

The outline is the same as though a cohesive filling were to be made. Care should be taken that the labial bevel be laid on the same plane as the travel of the wax pattern to exit, else this portion of the model will be distorted in removal.

The gingival wall should meet the axial wall at an acute angle and the cavity should have a line angle which might be termed axioincisal. The labioaxial line angle should be slightly shorter than the outline of the cavity where the axial wall meets the lingual surface. This will result in allowing the pattern exit to the lingual. As the labial wall, which is the seat of the cavity, is frail, care should be taken that it is well supported by sound dentine, else the seating of the inlay will cause fracture of this wall.

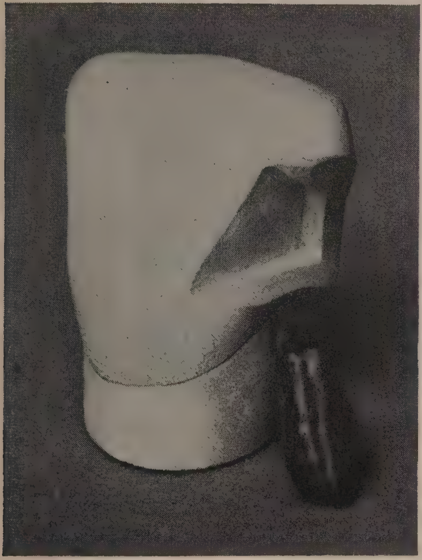


Fig. 110.

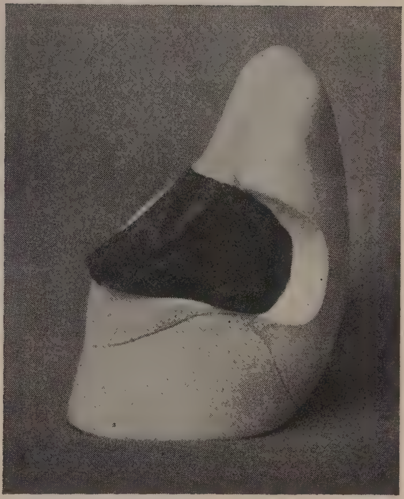


Fig. 111.

Fig. 110.—Cavity of Class Three for gold inlay, lingual approach. Cavity side of inlay shown.

Fig. 111.—Inlay shown in Fig. 110 partly in place.

Preparation of Cavities of Class Four

The use of the inlay should be largely restricted to pulpless cases, and a pin in the pulp canal should be used for the major portion of retention.

If the inlay is used in Class Four, plans one and three, the case should always be pulpless. In vital pulp cases the inlay may be used to advantage in plans two and four.

Resistance Form.—In this part of cavity procedure the same care should be exercised as when using the cohesive gold filling. This is particularly true at the incisal edge where the beveling to the axial should be quite generous to protect against the breaking down of this margin due to the fact that stress comes at right angles to the long axis of the enamel rods.

Retention Form.—This step in cavity procedure will vary according to which plan of Class Four is used. In plan one, which, as before stated, should be used only in pulpless cases, a pin should be placed in the pulp canal and

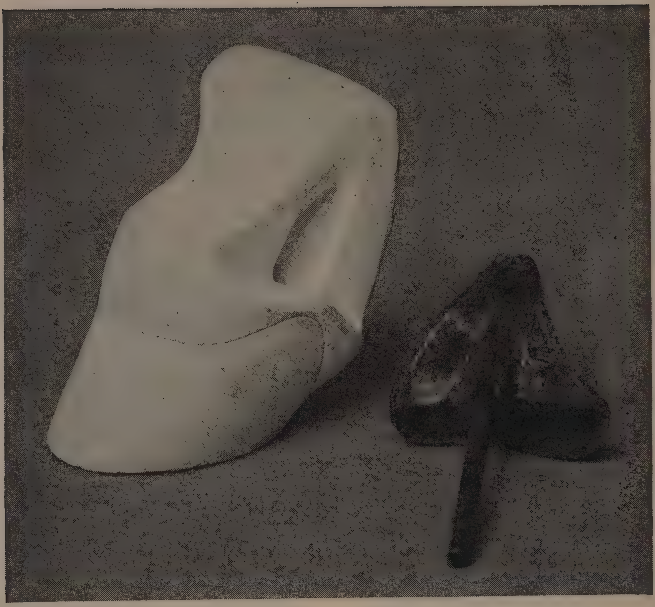


Fig. 112.—Cavity of Class Four, plan one, for gold inlay. Cavity side of inlay shown.

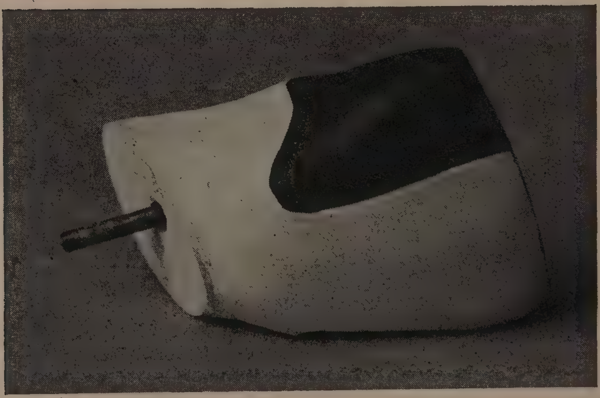


Fig. 113.—Class Four, plan one, inlay in position. Cavity shown in Fig. 112.

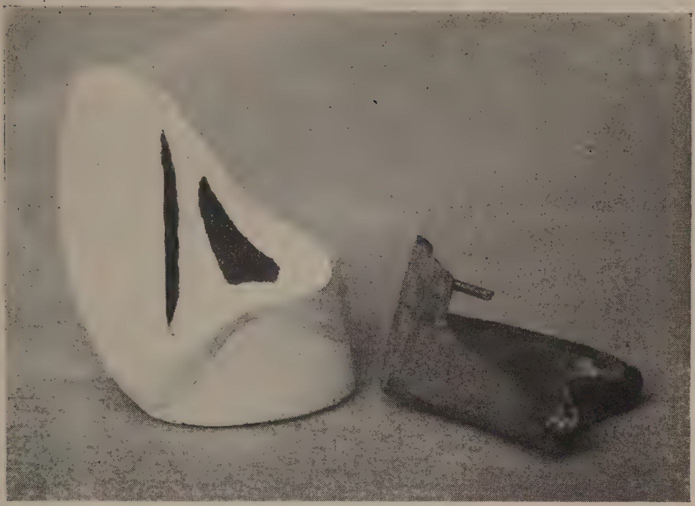


Fig. 114.—Cavity of Class Four, plan two, for gold inlay. Cavity side of inlay shown. Black wax has been used to temporarily remove undercuts caused by decay.

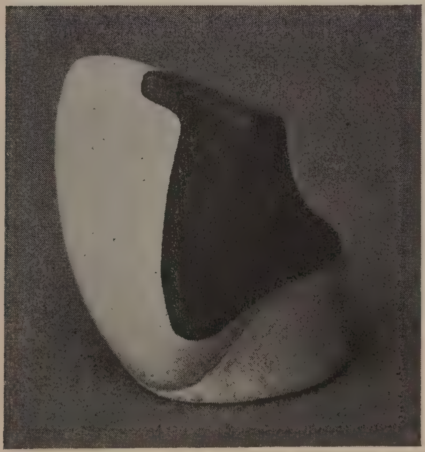


Fig. 115.—Class Four, plan two, gold inlay in position. Cavity shown in Fig. 114.

depended upon almost entirely for the retention. In plan two, largely used in cases with vital pulps, a short, 20-gauge pin of iridioplatinum or tungsten should be placed in the step portion of the cavity lying parallel to the long axis of the tooth. This small pin had best be from one to three millimeters long, owing to the possibilities of the case. The gingival retention may be accomplished either by a pin similar to that used in the incisal, placing the hole for it in about the center of the gingival wall, or by the plan of retention used in the gingival wall of Class Two. This consists in cutting the two convenience angles in the gingival wall. In plan three, pulpless cases, the pin in the root canal should be used. In plan four, the same retention should be used as in plan two, as the case is nearly always vital.

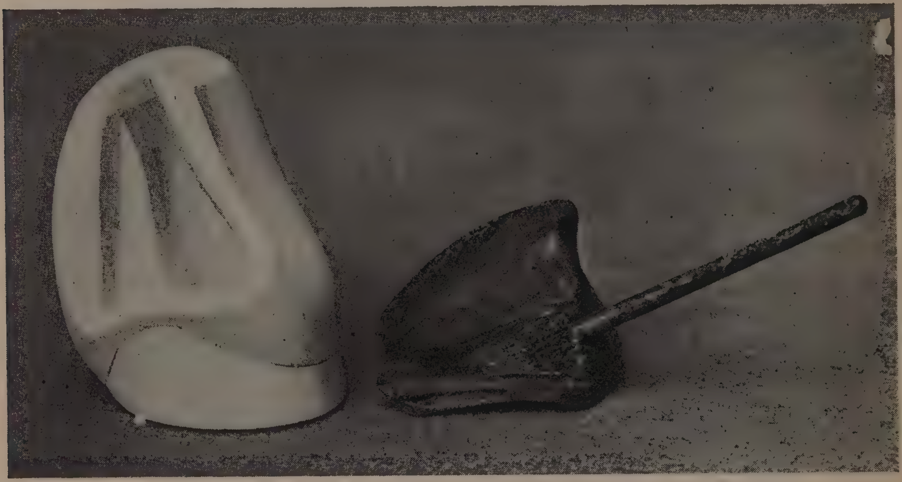


Fig. 116.—Cavity of Class Four, plan three, for gold inlay. Cavity side of inlay shown.

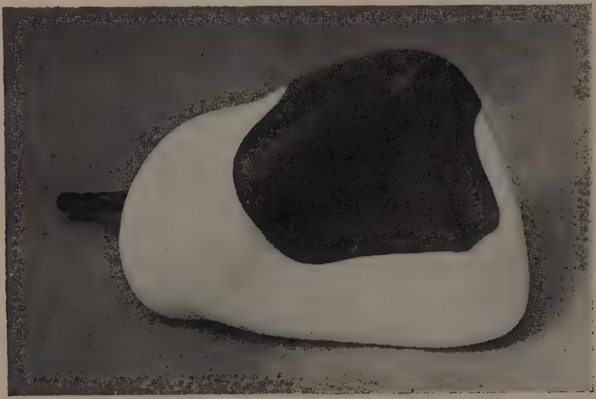


Fig. 117.—Class Four, plan three, inlay in position. Cavity shown in Fig. 116.

The enamel walls should be well beveled, which will in no way hinder the removal of the model. Model should make exit to the incisal with a slight lingual travel.

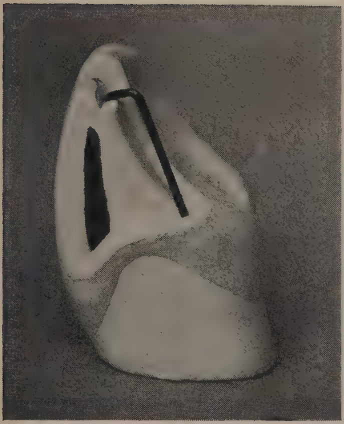


Fig. 118.

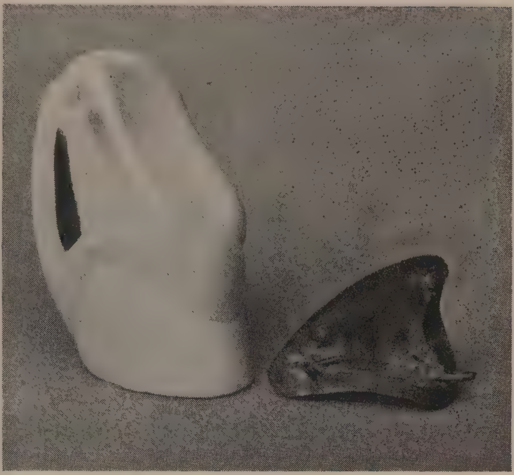


Fig. 119.

Fig. 118.—Cavity of Class Four, plan four, for gold inlay. Black wax has been spread on the labial wall before making the pattern to prevent the gold from touching this wall when setting the inlay. This is done for two reasons: first it removes the liklihood of fracture of this wall when setting the inlay; second, this wax is replaced with cement and the color of the tooth is preserved. The wire loop secures the alignment of the two posts and facilitates handling the pattern. When the wire is not entirely buried, platinized gold should be used. When it is entirely buried, tungsten may be used.

Fig. 119.—Class Four, plan four, showing cavity side of pattern with pins.

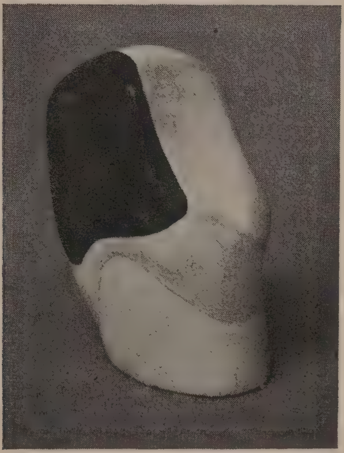


Fig. 120.—Class Four, plan four, inlay in position before removing wire loop. Cavity and pattern shown in Figs. 118 and 119.

Preparation of Cavities of Class Five

The large buccal cavities of this class call for gold inlays, which are the ideal filling and should largely replace the amalgam so commonly used.

The Occlusal Wall.—The axioocclusal angle should be slightly obtuse, while the axiomesial and distal angles may be nearly right angles. This will permit the model to tip to the buccal in exit, even though the gingivoaxial angle be acute.

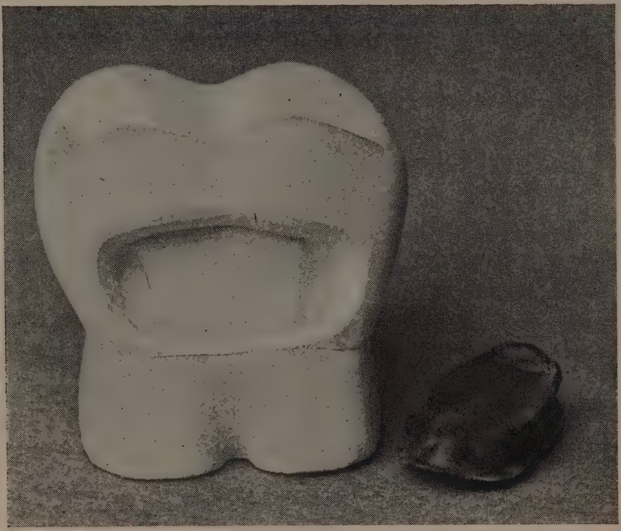


Fig. 121.—Class Five cavity and inlay.

Preparation of Cavities of Class Six

The restoration of abraded surfaces with the gold inlay is good practice, inasmuch as it is possible to protect these surfaces effectually from further destruction with the minimum amount of cutting. As is the case with the other forms of filling, the surface covered should be generous. If only one tooth is to be treated with this filling, the amount of tooth substance cut away will be about the same as the quantity of gold in the inlay.

If the bite is to be raised on most or all teeth, however, the cutting should be very slight, only enough to properly cleave and bevel the enamel margins.

In vital pulp cases, either incisal, lingual, or occlusal, the retention should be made by introducing short pins, iridioplatinum or tungsten preferred, through a matrix of pure gold, and then casting the contour.

In pulpless cases a single large pin should be used, or the model may be so made as to occupy a part of the pulp chamber in lieu of the pin.

CHAPTER XXXI

THE MAKING AND SETTING OF A GOLD INLAY

In discussing the methods of making any filling, particularly the gold inlay, one must bear in mind that the best practice today may be obsolete tomorrow. In this chapter an attempt is made to bring out only the most popular methods at this time, as we are fully aware that new methods are continually being devised, which may prove of better service. In fact, since placing the earlier editions of this book on the market, there have been material changes in methods, which have resulted in much improvement in this class of fillings. There is a question in the minds of most of our prominent teachers, however, as to the comparative value of this method when considering the cohesive gold filling. If the excellent results obtained in the use of cohesive gold are to be approached in the use of the inlay, great care and pains must be taken with every little detail.

The Object of the Inlay.—The object of the inlay is to protect the cement which covers the cavity walls and restore lost contour.

If cement were permanent in the mouth when exposed to wear and dissolving agents, there would be no call for inlays, which are really made only to protect the cement. It is therefore of the utmost importance that the inlay completely cover the cement by a perfect adaptation at the cavity margins and that it be so constructed as to maintain this close adaptation.

In choosing the method of construction in each case, the marginal adaptation should be considered and the method selected which promises the nearest to perfection.

History.—The inlay is probably the oldest form of filling, as proved by excavations in the Orient. Teeth in the skulls of mummies have been found, wherein cavities have been crowded full of lead, with the probable intent of checking decay. Even in modern times the inlay has always been used more or less and has become more popular as time goes on. As compared with the making of a cohesive gold filling, it is infinitely easier, and the history of our college clinics shows that the beginner attains a passing degree of success with the gold inlay long before he is able to understand and successfully bring to bear many of the qualities of cohesive gold.

Method Using Pattern Entirely of Wax.—The cavity should be prepared as outlined by classes in Chapter XXX. In case decay has left the cavity so that it is retentive in all directions by having excavated undercuts, these should be filled with some substance which does not become a part of the pattern and which is easily removed before setting the inlay. The substances used to remove the retentive form temporarily are: cement, temporary stopping, modeling compound, and wax, the preference being with the wax. This wax should be of a decidedly different color from that of which the pattern is made. (See Fig. 122.)

The filling of the undercuts should be made to dry cavity walls, with the wax quite warm to insure its adhering, that it may not leave the walls to distort the pattern. The difference in the color of wax used will cause the detection of any particles which may adhere to the pattern and so make their removal easy.

By a little study and the judicious use of the above method, much cutting for convenience form may be obviated and many seemingly difficult cases rendered quite simple.

The Making of the Pattern—Direct Method.—After the retentive form has been removed, the cavity should be flooded with water of ordinary temperature. This will render the wax within the cavity sufficiently hard not to yield under the force necessary to introduce the pattern wax. It will also prevent the portions of wax from adhering. The wax for the pattern should then be softened, preferably in warm water. The wax should be sufficiently plastic to permit molding when manipulated in the fingers, care being taken that the wax is not folded upon itself, as the portions will not adhere. Wax so folded is liable to part at the folds and come away from the cavity in sections. The wax should be gently shaped so that it can be introduced into the cavity in such manner as to come in contact with the base walls or floor of the cavity first, then by slow continued pressure for about fifteen seconds made to expand till it entirely fills the cavity, overflowing all margins.

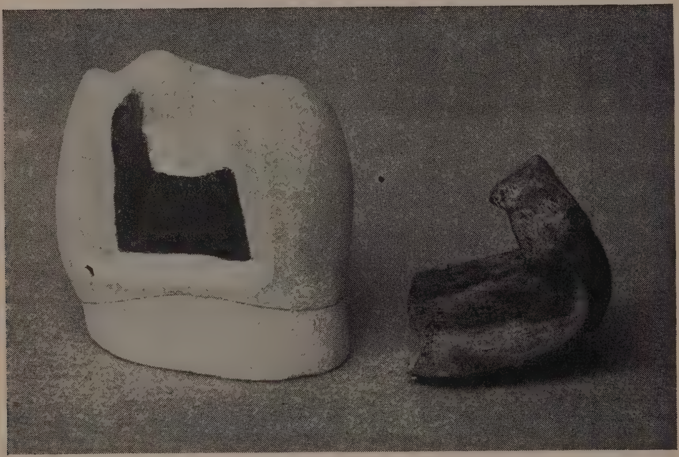


Fig. 122.—Large restoration in pulpless case. Part of the pulp chamber has been filled with black wax to remove undercut caused by pulp removal. The weak buccal wall has been covered with the same material to protect it from stress from within when setting the inlay. It goes without saying that this wax is all removed before the inlay is set and is therefore replaced with the cement with which the inlay is set.

If the inlay is to replace any portion of the occluding surface, the operation should be done with the rubber dam off. The patient is requested to close the teeth to full occlusion, slowly. It must be remembered that the casting wax is only semiplastic and moves very slowly, hence the best impression is obtained by moderate continued force, giving the sluggish wax time to flow. Wax is really quite elastic when confined, and when the pressure from the bite is removed it will spring back the least bit, so that the cast inlay will be too high when set.

To overcome this, it is good practice to have the patient again close the teeth to occlusion with one layer of rubber dam over the occlusal surface of the model, requesting him to maintain the pressure for some seconds. The elasticity of the rubber dam will overcome the elasticity of the wax. This will do away with much grinding after fitting the inlay to position. The pattern should then be carved to full contour restoration and correct external surface form, and the wax thoroughly burnished around the entire cavity outline.

The carving and burnishing of the wax are materially assisted if the surface is warmed by the use of warm water. This is best accomplished by dipping large, loosely-rolled cotton balls in water that is almost too warm for the fingers, carrying it to the mouth and folding about the wax, allowing it to remain for a few seconds. Upon removing the cotton, the wax will be found to have softened to a sufficient depth to be easily manipulated. In case the wax does not quite reach the margin, it should be crowded over to the margins, carrying quite a body of the wax over before attempting to burnish down to the margins. If this is not done, the wax will be found to fit only at the cavosurface angle, leaving a space just below this point to which the wax is not adapted.

Ideal conditions are obtained when the wax slightly overlaps the cavosurface angle at all points in the outline, about one-tenth of a millimeter.

This will give sufficient bulk for correct finishing. After the completion of the pattern it is well to insert the tine of an explorer to the depth of about one or two millimeters in a convenient position for removal.

The tine should be removed and the pattern chilled with cold water, the tine reinserted into the previously made hole, the pattern gently pushed to exit and then given a cold water bath.

The Placing of the Sprue Wire.—While the pattern is still carried on the tine of the explorer, the sprue wire should be warmed and inserted.

The sprue wire should be very fine, preferably of copper, and introduced deep into the pattern. This use of a fine sprue wire is of advantage from the fact that no considerable body of the wax melts and runs back up the wire to produce a concavity close to where the wire is introduced, which happens when a large sprue wire is used.

In selecting the position for the wire, care should be taken that a location is chosen so that the contour of the surface of the pattern leaves the sprue wire in all directions at an obtuse angle. A neglect of this point will occasionally result in imperfect casts near the sprue former. The tine of the explorer should now be withdrawn and the resulting hole sealed by touching with the warm end of a small instrument. A good instrument for such work is the flattened end of a large canal cleaner or broach, mounted on a wooden handle.

Giving the Wax Pattern Retention Form.—Portions of the pattern should now be removed, preferably by the use of the heated hollow needle, in such manner as to give the cement an ample grasp upon the inlay, and should be equal to, or more than, the amount of retention of which the cavity in the tooth is capable. The pattern is then ready for investment.

Method of Using Wax Pattern, Pin Attached.—This method is of service when, for any reason, it is desired to have the maximum amount of retention. In such cases the tooth will generally be pulpless and a portion of the pulp cavity will be used for the reception of the pin.

Placing the Pin.—The cavity should first be freed from retentive form as described above, using either cement, temporary stopping, modeling compound, or wax; then an opening could be made in the root canal to receive the pin, which is placed in position with a light coat of sticky wax on the outer end. The pin should be long enough to reach well into the body of the wax pattern and should be iridioplatinum, platinized gold, or tungsten. These materials will stand the heat of casting the inlay without alloying or losing their rigidity.

Stellite Pins.—The use of tungsten in casting gold inlays is of great advantage, as this material is easily cast upon when the wire has been previously gold-plated. The wire is inexpensive and very strong and will not discolor the teeth. This material does not lose its temper upon being heated. It therefore gives us a very rigid pin in the completed work. As the gold will not cast to the end of the pin, which has been cut off and is not gold-plated, it is very essential that these exposed ends be well buried in the wax, which can be accomplished by seeing that the pin does not come near the surface of the casting, or else that the end is bent so as to throw the exposed surface more deeply into the wax pattern. With the pin in position in the cavity, the wax for the pattern is manipulated just as though no pin had been used. When the pattern is withdrawn, the pin should come away with the wax. In case it does not, withdraw the pin from the tooth and seal it into the hole it has left in the wax pattern and return to position to insure alignment. Withdraw the pattern after chilling and all is ready for investment.

Method of Using Pure Gold Matrix With Pin Soldered on. Casting the Contour.—This method is advised as most practical in cavities of Class Four (first plan), when teeth are pulpless, also in incisal, occlusal, and lingual restorations with or without vital pulps. With these lingual restorations, the amount of surface covered is generally quite large as compared to the thickness of the restoration, which is best termed an "onlay."

This method simplifies angle restoration in Class Four, plan one, and provides ample resistance form without the cutting of either the incisal or lingual step. In such cases the alignment of the pin must be perfect, else the inlay will not go to proper place. The soldering of the pin to a gold matrix gives the desired security during the processes of removing and investment. The cavity preparation is the same as for cohesive gold except for the convenience angles. The pin is fitted to a portion of the root canal as previously given. A sheet of pure gold, 32 to 34 gauge, is selected, of sufficient size to more than cover the cavity by about two millimeters. This is partially burnished to the cavity, enough to show the cavity outline in the gold. A hole is punched in the proper position to receive the pin, but smaller than the pin, which should be 15 or 16 gauge. In case the inlay is to be used as an abutment for a bridge, the pin should be as large as 14 gauge if platinized gold is used. When stellite is used, 16 gauge is ample.

The operator should then place the matrix in position and crowd the pin through the hole to place; then scribe the pin just external to the gold matrix, remove and solder as nearly in correct position as possible without stopping to invest, using 22k solder.

Only a very small amount of solder will be needed or should be used, care being taken that it is all flowed close to the pin to prevent stiffening the matrix. All should then be returned to the cavity and the gold reburnished to a perfect fit of the entire cavity outline.

It is necessary to burnish the gold only partially into the deep recesses of the cavity, as the pin, if of iridioplatinum or stellite, will be sufficient anchorage. This can be made to equal that frequently relied on for an entire crown. This pattern must move to the incisal for exit, and, if the matrix is burnished to contact with the axial wall, it will become fixed. The matrix should be burnished to a complete fit of the gingival wall which should be flat and well squared into the labial and lingual angles.

Making the Wax Contour.—The matrix and attached pin are removed, and the desired contour built up by flowing the wax to position with a spatula, trying the whole pattern to place in the cavity to guide in the restoration. When complete, the wax is chilled and removed, and all is ready for investment.

To restore occlusal and incisal surfaces lost from abrasion with inlays where the tooth is vital, nothing answers the purpose better than the following method. The outline of the surface to be covered is established. Small holes are drilled to convenient depths in safe locations of sufficient size to receive a 20 gauge iridioplatinum or tungsten pin. Three or four pins are required for molars and two or three for bicuspids or incisors. A pure gold matrix, 32 or 34 gauge, is then burnished to an approximate fit. The positions of the holes in the tooth will be outlined in the gold. The matrix should be pricked at these points with a sharp-pointed instrument smaller than the pins. One pin is inserted and should protrude occlusally through the matrix for a short distance and be bent at right angles.

It is good practice when using stellite to make a loop which goes to the full depth of two of the holes and lies along the gold surface in the body of the loop, thus establishing the alignment of two of the pins at once. This also places the exposed end of these tungsten pins, to which gold will not cast, entirely away from a position which might result in showing the exposed ends in the completed case.

This pin and matrix are then removed and attached with solder, applying the solder to the occlusal side of the matrix. The matrix should be returned to the tooth and another pin placed and attached in the same way, repeating until all pins are in position, when the matrix should receive a final burnishing. The wax contour is then added as before described, the pattern replaced, and articulation secured in the mouth and finally trimmed to desired contour. The wax should then be chilled and the entire pattern removed and invested.

Method of Sweating the Contour. Advantages.—The advantages of this older method of making an inlay still exist, where the inlay is to cover considerable surface and is very shallow. Such inlays are generally termed "onlays." This method is advised from the fact that models of such nature will seldom maintain exact form during the process of removing and investment unless a gold matrix is used.

If the gold matrix is used, it is difficult to cast a thin layer of gold over the entire surface of this matrix and get good margins unless a large quantity of gold is melted to make the cast, in which case the gold matrix is very liable to be entirely fused, which will not give the best results. Speed is also a factor in this instance. Many times an onlay can be flowed to the desired thickness in much less time than that required to invest and cast.

Making the Matrix.—This is done in the same way as though a greater bulk of gold were to be added. Such inlays must be retained by one or more pins soldered to the occlusal side as previously described.

The matrix is burnished to perfect fit and the outline definitely established. The matrix should be trimmed to within about one-fourth millimeter of the cavity outline, reburnished, and carefully removed.

The matrix is then given a coat of whiting on all that portion which is to come in contact with the tooth, to prevent the solder from flowing on that surface.

Sweating the Contour.—The gold matrix should then be laid upon the soldering block and, with a brush flame from the blowpipe, 22k plate or 22k solder should be fused to the thickness desired in the various locations on the matrix. When a sufficient amount has been fused in any portion, that part of the surface should receive a coat of whiting.

Gold can then be fused to the still exposed surface without its spreading to portions where it is not wanted. By this means it is possible to build up a given portion of the inlay, even to the adding of cusps to the occlusal surface.

Method of Using Sponge Gold as a Pattern.—Take the sponge gold as bought on the market for making a cohesive gold filling, and saturate it with any casting wax. This is best accomplished by dipping a sufficient amount of the heated gold, while held in the pliers, into the molten wax, and immediately removing to a clean surface to cool. Remove any excess wax.

Making the Pattern.—When this method is used, any undercuts in the cavity should be filled with cement. A portion of the saturated gold, a little more than enough to fill the cavity, is grasped between the pliers, slightly warmed, and carried to the cavity. It is crowded to position and the contour determined in much the same way as amalgam is manipulated. A matrix should be used in Class Two cavities, but not sufficiently high to prevent occluding the teeth. When the pattern has the desired contour form, the whole is removed as described for removing a pattern composed of wax alone.

Investing.—A sprue of wax is attached to the usual place as though the casting method were to be used. The pattern is then submerged in much the same way as a tooth is invested to have a backing flowed, but sufficiently deep upon the wax sprue former to leave upon its removal a receptacle for the gold solder to be fused.

Saturating the Model.—Heat may be applied to the invested pattern as soon as the investment has set, and the wax gradually burned out, leaving a framework of pure gold filling the mold. Then scraps of 22k gold plate are placed in the hole left by the sprue former and all is heated to the point of fusing the 22k gold, which will disappear through the opening and completely saturate the pure gold within the mold. The inlay may be immediately chilled and finished. This method has speed of manipulation to recommend it, and is indicated in large contour restorations where it is desired to use a solid inlay.

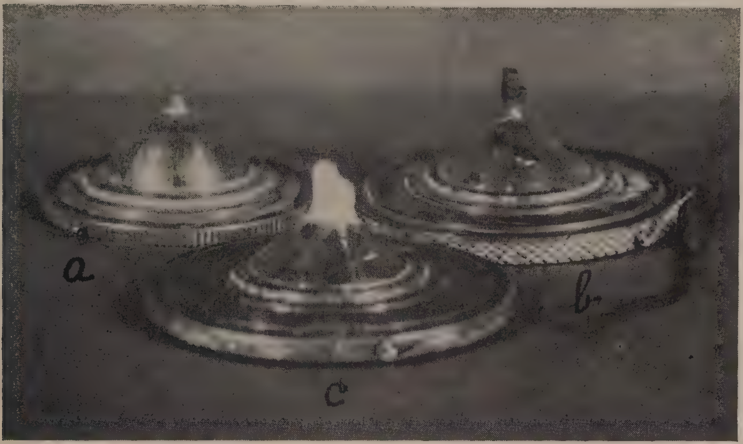


Fig. 123*A*.—Giving the pattern the first investment. *a*. Hollow tube to receive a small service wire. *b*. Pattern attached. *c*. Pattern painted with Cristobalite to receive the dust for sponge. Note that the cavity side of the pattern is uppermost.

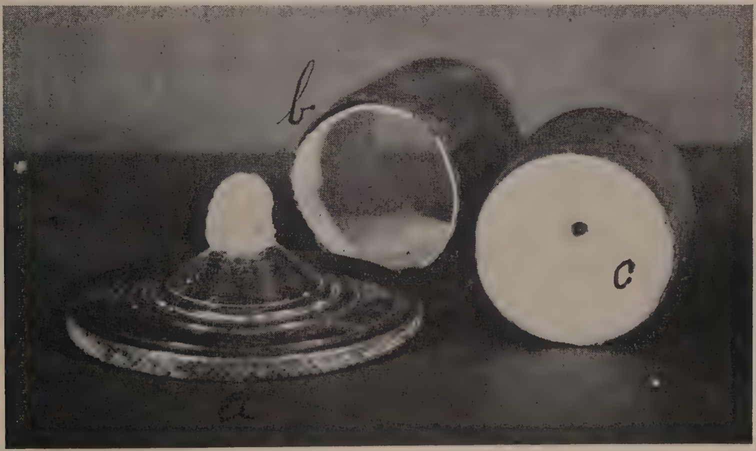


Fig. 123*B*.—This, as invested, is immediately placed in a dish of water of a temperature of about 100° F., to remain so immersed for about thirty minutes to secure hydroscopic expansion of the pattern.

Method of Investing.—After much experimental work, the following technic for investing the wax pattern seems to produce the most uniform results as to duplication of all classes of patterns.

The small copper wires are secured by burning the covering from an ordinary electrical service cord and using one of the eight or ten small wires exposed, cutting the wire to about 2-inch lengths. (Fig. 123*A, b.*) One of these wires is attached to the portion by heating the end red-hot and pushing it deep into the wax. The wire is then threaded through a hollow pin and the pattern drawn down tight to the end of the hollow pin and off to the side, to be wound around a post in the edge of the sprue former, holding the pattern firmly in position. (See Fig. 123*A, c.*)

Investing Patterns.—Much research has been done to bring out a casting which is clean of surface and an exact reproduction of the pattern used. The varying thermal changes through which the wax pattern and the investing material must go to produce a gold inlay has very seriously affected and complicated the work. Volumes have been written on the subject. Many materials have been advocated and many technics advised to minimize the dimensional changes in the wax, the investments, and the gold used. No attempt will be made to go into the details of this research as it would waste much time. We would rather advocate the materials and a technic which have been proved to produce satisfactory results without costly equipment and are so simple that the beginner as well as the busy practitioner may readily use them.

We designate this method as the ''Triple Investment.'' The pattern is secured to the sprue former as previously described and shown in Fig. 123*A, b.* The pattern is dried with the hand chip-blower, and the pattern thus mounted in place near an electric light and brought to a temperature of about 98° F. A small rubber bowl is dipped into hot water. A teaspoon full of hot water is left in the bowl, to which is added a sulfide-free investment (Cristobalite) to make a workable batter. This mix is then painted on the pattern with a small fine-haired brush, about No. 1, to cover the pattern to about one-half to one millimeter thick as shown in Fig. 123*A, c.* This is allowed to set for about two minutes. This constitutes the first investment. Another small mix is made of the same investment material and a second coating is made over the first to the depth of about two millimeters. Into this is immediately dusted fresh dry investment till the powder ceases to turn dark. The excess dry powder is blown away. Do not press or pack this in any way. This constitutes the second investment known as the sponge, as shown in Fig. 123*B, a.*

A ring or flask is selected and lined with asbestos as shown in Fig. 123*B, b.* The ring is placed on the sprue former base and filled with Standard Crown and Bridge investment, mixed rather thin to purposely produce a shrinking third investment. (Fig. 123*B, c.*)

Length and Gauge of Sprue.—The shorter the sprue and the larger the gauge, the more uniform will be the texture of the casting. (Figs. 124*A, B, C, D,* and *E.*)

The author prefers, for general use, a sprue one millimeter long and a gauge of two millimeters.

The wax pattern should be as near the center of the bucket as possible, as in this position it is the least affected by dimensional changes in the investing materials. True to the law of physics, these investments shrink to, and

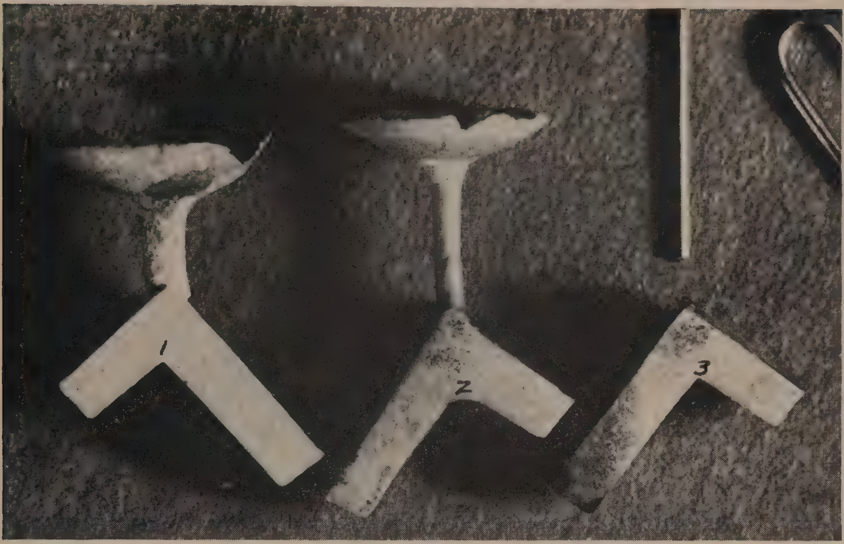


Fig. 124*A*.—Three castings of approximately the same weight and shape but made with three different length and diameter sprue attachments. The castings were made under as near the same conditions of investing, heating, etc., as possible. The specimens were highly polished and etched with aqua regia for one minute in order to make the deficiencies already present more pronounced in appearance.

Figs. 124*A*, *B*, *C*, *D*, and *E* are from microphotographs by Donald A. Keys, A.B., D.D.S., Chairman, Department of Operative Dentistry, College of Dentistry, University of Nebraska, and presented before the Dental Materials Group, International Association for Dental Research, Chicago, March 18, 1944. They were published in the *Journal of the American Dental Association*, volume 32, January 1, 1945, and are here reproduced by permission.

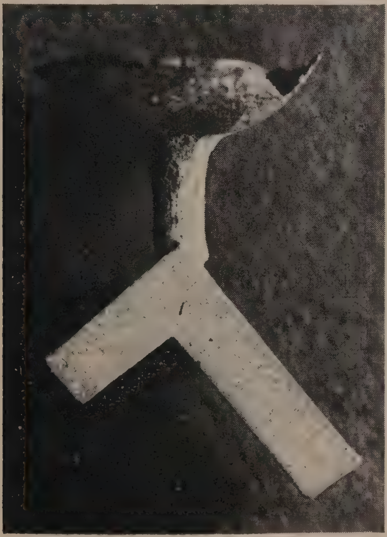


Fig. 124*B*.

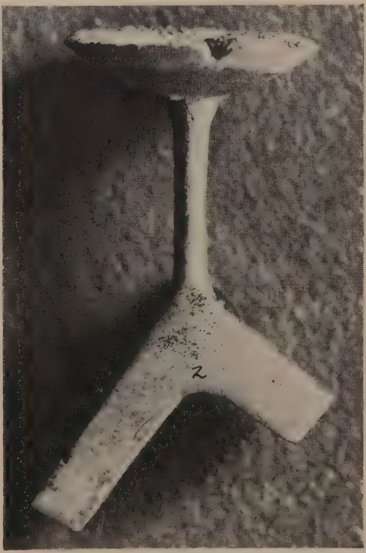


Fig. 124*C*.

Fig. 124*B*.—Casting No. 1. Sprue attachment was ¼ inch in length and 2 mm. (12 gauge, standard wire measurement) in diameter. The casting is magnified 10 diameters. Weight, 38 grains. Note the fine density and uniform grain structure throughout the casting.

Fig. 124*C*.—Casting No. 2.—Sprue attachment of 1.5 mm. or 14 gauge in diameter and ½ inch in length. Casting weight 36 grains. Note the localized porosity at right of sprue due to small size of "feeder" for the bulk of the casting.

expand from, the center of the bulk; hence the farther from the center, the greater the movement.

With these facts in mind, we use a bucket that is only as long as it is wide.

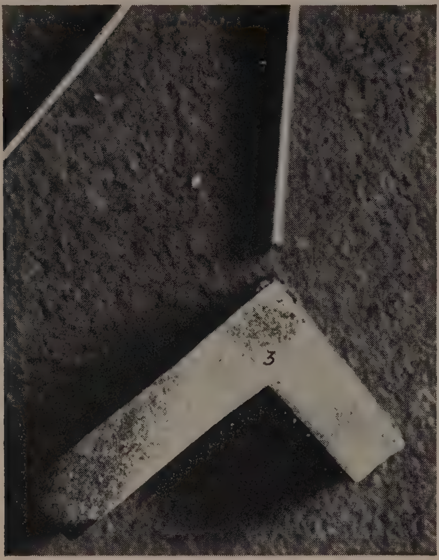


Fig. 124*D*.—Casting No. 3. Sprue attachment of 1 mm. in diameter, 17 guage. The major part of the casting exhibits a porous condition due to the inadequate sprue size. Extreme porosity is seen at the greatest extension arm. Casting weight, 36 grains.

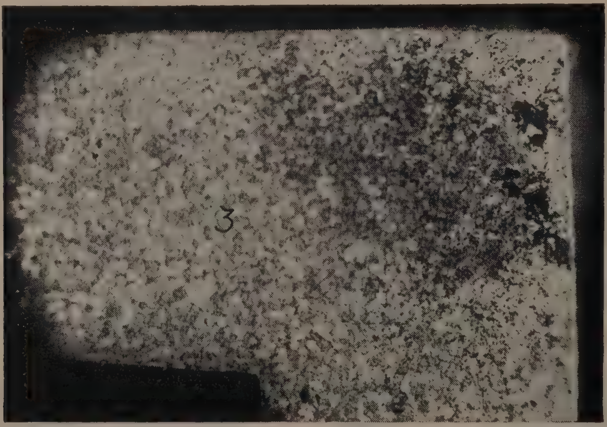


Fig. 124*E*.—Magnification (×25) of Fig. 124*D* showing voids and deficiencies in one area of the casting.

Burning Out the Wax.—When the investment is set, remove the sprue former, and, with an operative chisel, ream out the hole to a clean surface. Use a No. 10 chisel for a small inlay, a No. 15 for a medium-sized pattern, and a No. 20 for a large pattern. Following this, direct a stream of hot air from the hot-air syringe in the hole to remove any loosened particles of investment. The investment-filled ring is then placed sprue end near a gas flame or electric toaster to dry out. As the moisture is evaporated in this end of the flask, the wax will melt, coming forward to occupy the space in that portion of the flask toward the sprue. Very little of the wax, if any, will enter the investment on the cavity side of the pattern. The heat should not be sufficient to boil or fry the wax from the hole. Continue the heat until all moisture has been removed from the investment. This can be ascertained by holding a bright cold instrument near the back end of the flask for a second. If moisture is still being driven out, it will congeal on the metal.

When the moisture has been dissipated, a blowpipe flame should be directed into the face of the flask, heating the investment to a red heat.

Gold Carat for Inlays.—There is no doubt about the late Dr. Taggert being right when he said, ''Pure gold is superior to any of the alloys for inlays,'' when used for the simple inlay under normal conditions. We must prepare, however, for the severe use to which most fillings are liable to be exposed during their life. For that reason, the gold alloys have become the favorite.

One should remember that the combination of various metals with gold has a marked effect on the behavior of the product when used to produce a casting. Much depends on the metals used, the amount of each, and the method of combining. There should be an absence of copper, zinc, and iron, frequently met with as contaminating metals. Copper is sometimes intentionally placed therein to give hardness and color to low carat alloys. Zinc accidently finds its way in when the dentist fuses for reuse inlays previously set with oxide of zinc cement, and iron enters by careless handling.

The sprue with the additions should be brought to a thorough fuse on a charcoal block, sprinkling the molten mass with a reduction flux each time before placing on the tray to make the cast. When set but while yet red-hot, the fuse should be dropped into cold water to crack away the borax glass. This treatment will remove the contaminating base metals, and the sulfides, oxides, silicate, and lime picked up from the hot investment of the previous cast.

A gold of not less than 22k, properly alloyed and used with an investment from which the sulfides have been removed, should bring a casting when taken from the flask that is the color of polished gold.

Making the Cast.—Much research has been done on the thermal phase of casting gold inlays, and the arguments are still in progress. The size of this volume does not permit going into the details. We are not going far wrong, however, when we heat the gold until it is thoroughly liquid and the external surface of the investment is a light yellowish red, and spring the trap. The first or inner investment will probably be between 750 and 1000° F.

Chilling the Cast.—As soon as the cast has been made, and while the gold is yet hot, drop the flask into cold water to remove the temper. This treatment is reversed with steel and iron.

Results of This Technic.—The mass is pushed from the ring and, if broken open as shown in Fig. 125, will reveal a casting of bright yellow gold. The first thin investment will have been baked to a brick hardness, generally red, and will be surrounded by the sponge or second investment, which will have turned black, and will have outside the third investment and the asbestos lining.

Preparing the Inlay for Setting.—Pickling in acid is not needed; in fact it will discolor the inlay. The inlay is cut from the sprue and partially dressed on the external surface before fitting. If care has been taken to properly paint the first investment on the pattern, there will be no sprues or rough elevations to show that the gold has penetrated the investment in even the finest spaces.

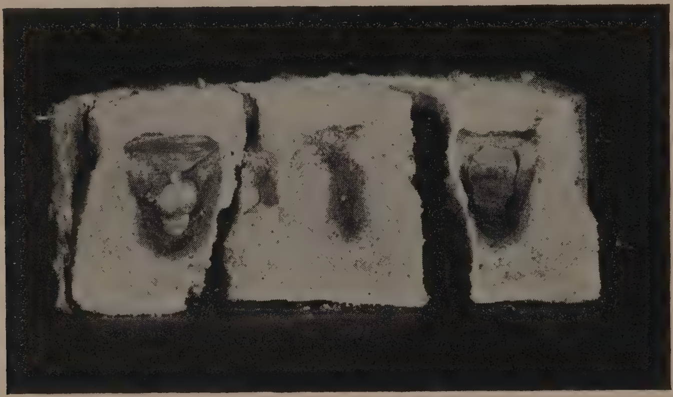


Fig. 125.

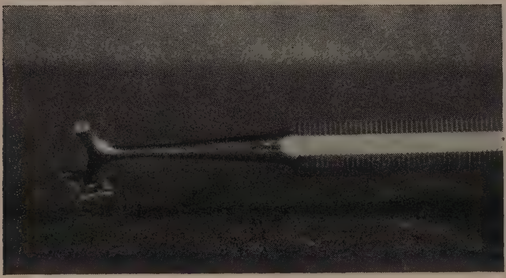


Fig. 126.

Setting the Gold Inlay.—When the external surface has been shaped, sized, and polished, it is ready to set in the cavity. The casting should be dropped into spirits of chloroform (alcohol 89 parts, chloroform 11 parts) to remove any contamination from handling, then placed in a convenient position. The open cavity should be dried and scrubbed with spirits of chloroform. The cement, properly mixed by adding the powder in small amounts, should be quickly placed in the cavity and on the inlay, the filling pressed into place, and then given a few tapping blows for final seating. It is good practice to place a few pounds of pressure on the filling for two or three minutes, after which the pressure may be released and a coat of cavity varnish smeared over the excess cement and the patient allowed to rinse the mouth with water. In five or ten minutes the excess cement should be removed and the occlusion tested for the final correction. Final polishing may be done at once provided no heat is produced and the jarring is but slight.

It is better practice to defer final polishing to the next sitting. Some inlays are loosened by the finishing while the cement is in the process of setting.

Small inlays, gold or porcelain, are difficult to set in posterior positions. Carrying the small inlay to a position which is hard to reach may be simplified materially by attaching the external surface to an angle instrument with sticky wax, as shown in Fig. 126. The cement is added to the inlay after so mounting.

Other Methods.—Up to this time we have dealt with the direct method only.

We have, however, the indirect and the direct-indirect methods, both of which have many advocates. The best method to use depends upon the cavity, the patient and the time in minutes available for chair work, the laboratory help available, and the dentist's familiarity with a given method.

The fit obtainable by any one of the three popular methods depends primarily on an exact impression of the cavity.

With the indirect method, the tooth's cavity, the tooth, and the adjacent teeth, if any, are modeled, and the procedure from there on is not unlike the direct method.

With the direct-indirect, the impression of the cavity and tooth is taken in casting wax and allowed to cool partially while under pressure, and the wax which has filled the cavity is retained as the wax pattern. The casting is poured up of the regular inlay investment.* The margins of the pattern are melted down in place of carving as there is likelihood of injuring the casting.

The technic of investing and casting is the same as in the indirect, except that the pattern that is taken from the mouth should be brought back to as near body temperature as possible, whereas the pattern in the strictly indirect method is generally invested at room temperature.

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*Cristobalite, Steel's, or R. and R. gray.

CHAPTER XXXII

AMALGAM FILLING

Definition.—Amalgam is an alloy of mercury with one or more other metals. It is most commonly combined with two or more other metals which have been previously alloyed, finely divided, and graded as to size of granules to facilitate union with mercury.

The properties of amalgam which render it of value as a filling material are: first, its plasticity which eliminates access form in cavity preparation, making possible the building up of lost contours in inaccessible places in the mouth, where convenience and access forms are hard to secure, sufficient for the manipulation of gold either cohesive or as an inlay; second, its property of being but slightly affected by the oral fluids, and the fact that it is fairly stable as to bulk and shape; and last, but not least in the minds of many patients we are sorry to say, is its cheapness, as most dentists see fit to build fillings of amalgam for a much smaller fee than gold or silicate.

The objections to amalgam are: its tendency to tarnish on its exposed surface; its discoloration of surrounding dentine in case of leaky fillings; its changes of volume during and after hardening in low-grade alloys or faulty manipulation. It is also liable to injury between the time of introduction and complete setting through carelessness of either dentist or patient.

Cavity Preparation for Amalgam.—Many of the failures in the use of amalgam attributed to the property of the material used are in fact due to laxity in cavity preparation, since many practioners believe that thoroughness is unnecessary in this particular. The preparation of a cavity for the reception of amalgam is even more exacting than for gold except when building into unset cement, as the operator is dealing with a filling material possessed of a greater number of faults, each of which must be given consideration. The cavity should be prepared in such manner as to minimize these to the greatest degree. In comparing amalgam with gold it might be said that amalgam requires less access in awkward localities in the mouth, requires more separation in proximal fillings, and that the outline form must receive more careful consideration as the margins must be farther removed from positions of great liableness to caries as well as to stress.

Flat seats for fillings are even more imperative than with gold, and the occlusal step must be broader buccolingually. The enamel walls must be finished with as great care, with a cavosurface angle less acute, and a more deeply buried bevel angle. Cavities must have more retentive form, excepting when cemented to place. (See Chapter XXXIV.)

The rubber dam is essential because it is imperative that amalgam be built against dry, freshly cut walls and margins. It is as impossible to make a good amalgam filling as it is a good gold filling against moist walls. The residue from the saliva upon the walls will show leakage more quickly with amalgam filling than with the gold. When operators come to the full realization of this fact and manipulate all amalgam fillings with as great care as gold, with reference to dry conditions, the frequent failures of amalgam will be materially lessened.

The Matrix.—All cavities filled with amalgam must have continuous surrounding walls while packing. This will necessitate the adjustment of the matrix in cases where a wall is missing, and applies to all Class Two cavities which reach the occlusal surface.

The matrix should be thoroughly wedged at the gingival, to prevent excess contour at this point, and to secure additional space that contact point may be made close. It should be made of steel as thin as one-thousandth of an inch. It should be made to circle the tooth firmly either by ligating or by a retaining appliance, several of which are on the market. When two proximal fillings are to be built at the same time and in the same proximal space, two matrices are necessary, one for each tooth involved. Each matrix should be reinforced with modeling compound.

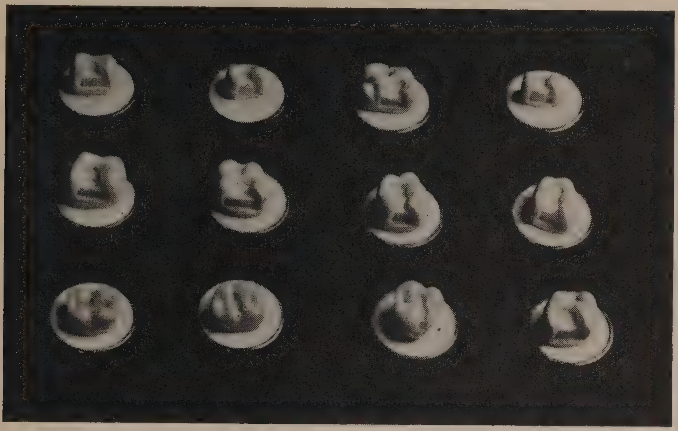

Fig. 127.—Photograph of teaching models suitable for amalgam and cohesive gold fillings.

Better results are obtained, however, particularly with reference to proper contact restoration, by building up and finishing one filling, and then building the other filling at a subsequent sitting. By using a specially prepared matrix band of the proper size for the second filling, with a hole cut in the matrix to allow the metal to protrude at the point of contact with the first filling, an ideal result may be obtained.

Separation.—Preliminary or immediate separation is just as essential in the use of amalgam as of gold.

Making the Mix.—The combining of the alloy and mercury to make amalgam brings about both a chemical reaction and a mechanical mixture. Assisted by the Bureau of Standards at Washington, the manufacturers have developed an alloy which results in an amalgam with slight but quite uniform expansion. The alloys of today are finer-grained, uniformly graded and proportioned as to size of granules, more nearly standardizing the product as it comes to the dentist, so that each batch is more nearly like the previous one used. It therefore follows that the best and most satisfactory results may be obtained if the manipulator in making an amalgam filling develops a correct and uniform method of mixing the mercury with the alloy and building the filling to further standardize the whole process. However, he is dealing with an expanding filling at this time. (Fig. 128.)

In making the mix, the right proportion of mercury to a given weight should be started with. This should show a slight excess of mercury when mortarization is complete. This has been accomplished when all grains or particles have been coated with mercury which is indicated when the mass becomes a glistening paste.

Further trituration should be avoided and the paste removed to the hand and made into a pellet with the least manipulation possible.

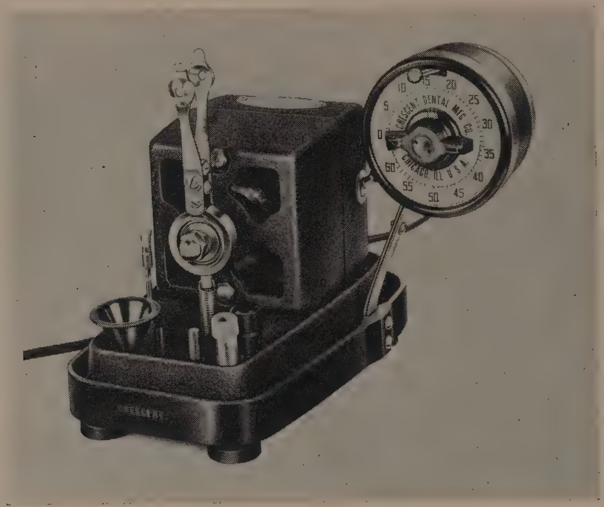

Fig. 128.—Wig-L-Bug. Amalgam mixer from the Crescent Dental Mfg. Co., 1839 S. Crawford Ave., Chicago, Ill.

Making the Filling.—The cavity should be in complete readiness to receive the amalgam immediately after it has been prepared. The size of the portions will depend upon the orifice of the cavity, and should be as large as can be easily crowded into the opening. This should be immediately compressed upon the seat of the cavity with as large a plugger as possible, with a rocking motion and as much weight as the circumstances will permit. When using a point that is much smaller than the cavity, the same wedging principle used in packing gold should be employed; that is, the central portion of the mass should be compressed first, and the walls last. A burnisher should not be used, neither should a burnishing nor wiping motion be used, but all compression force should be directed at a right angle to the base wall. Excess mercury should be scooped away.

Quite a body of excess alloy should then be added to the occlusal portion and a plugger point applied with mallet force, which should be augmented with hard hand pressure. The last portions should be drier, having had some of the mercury squeezed out. The hand pressure and mallet force combined will produce a more dense filling than any other method and at the same time crowd the yet movable particles of amalgam and alloy into closer relation and adaptation to every portion of the cavity walls.

Trimming Amalgam Fillings.—After packing, the amalgam should be allowed to set undisturbed for one or two minutes, when the excess may be cut away with suitable knives. Gum lancet No. 2 and the discoid and cleoid from the "University set" are serviceable, as are also the large spoon excavators.

Removal of Matrix.—The matrix should then be removed in proximal cavities by drawing to the buccal while pressing the ball of the finger gently on the occlusal surface. A loosely rolled, rather large ball of cotton should be laid on the amalgam filling under the finger tip, in order to prevent the matrix from traveling occlusally in the process of removal. (For removal of ligatures, see Chapter XXIII.)

The rubber dam should be removed and the patient instructed to close the teeth slowly, stopping the instant he feels the presence of the filling between the teeth, which will occur if excess contour has been built. With the teeth still held in this same position, the patient is requested to give the jaws a gentle side movement. This will result in burnishing the spots of contact, after which the excess should be whittled away with knife-edged instruments.

Amalgam should be cut from the margin to the filling, which is just the reverse from the travel of the instrument in cutting gold fillings. If the cutting instrument moves from the filling to the cavosurface angle with amalgam that is partially set, it is liable to sink too deeply into the substance of the filling and expose the margin as it crosses over.

Passing Contact Point.—In proximal fillings of amalgam, nothing should ever be allowed to pass the contact point until the amalgam has completed the process of setting, as one such attempt forever destroys proper contact, and a filling so treated becomes at once a makeshift. All overhanging amalgam should be cut away around the entire cavity outline, but the region of the contact point should be entirely neglected at this time and left for final shaping during the process of polishing. Finally, the filling should be gently wiped with spunk or cotton.

Polishing.—All amalgam fillings should receive as thorough and careful polishing as gold. This must be done at a subsequent sitting. In the proximal fillings the separator should be adjusted and the contact point properly formed and polished.

For this work only abradents of the finest nature should be employed. Burs, carborundum stones, coarse strips, and disks only do harm and prolong the operation. Fine strips, disks, wood points, and leather wheels using first pumice then whiting, and lastly the tooth-polishing rubber cups should be used.

Expansion of Amalgam.—Modern dental alloy is now so compounded as to result in an expansion amalgam. This expansion begins at the time of packing and continues for some little time thereafter.

This expansion has merit, particularly in some classes of fillings, but is complained of in some instances as an undesirable feature. With our modern conception of proper cavity preparation with its definitely locking line angles and point angles, the increasing bulk must move in directions away from this positive anchorage, positively lifting the filling off the marginal bevel. In cases with but a thin layer of dentine covering a vital pulp, either the pulpal or axial wall may be pushed or bent to encroach on the pulp. Dentists frequently report cases where distress to the patient has followed the placing of such an amalgam filling.

In large Class Two fillings, frequent reports are heard wherein the dentist feels sure that the amalgam has expanded to the proximal so that within a few weeks the buccal and lingual margins of the cavity are slightly exposed, and at the same time the filling at the gingival has been made to protrude slightly beyond the cavosurface angle; all this following in cases where great care has been taken to finish the filling flush with cavity margins.

Use and Abuse of Amalgam

In the history of dentistry the records show that more filled teeth have been saved to a prolonged service through the use of amalgam than by the use of any other material, in spite of the shameful abuse it has received at the hands of the dental profession.

The great number of teeth saved with amalgam has been due mainly to two factors: First, the materials which enter into the filling are comparatively cheap. Second, the material as used, and abused, took little time to build into a filling and lasted as long as the patient thought it ought to.

In the early days, the writer, as is the case with the older practitioners, changed from one make of amalgam to another and back again on the fluency of the speeches of the salesmen.

Then the manufacturers threw out the gold and platinum which never did amalgamate and threw in large percentages of zinc to make the amalgam easier to mix. During that period the public was served with the poorest dentistry of modern times. Trouble existed until the American Dental Association appealed to the Bureau of Standards for relief.

The investigation which followed soon proved the faults were twofold. First, in formulas and methods of manufacture; and second, in the faulty technic and shiftless habits of the dentist.

Those days are practically over now, as the certified amalgams are within range of possibility, with prime technic so thoroughly preached that those of us who really care may produce amalgam fillings which are time-enduring and rival all other fillings, not excepting those which look more rich. To date, they have not commanded the fees that gold does.

Moisture, though not commonly considered so, is the common enemy of all fillings being built in the teeth.

With cohesive gold, the wet cavity produces a rocking filling. With the cemented inlay, our research proves that within ten minutes from the time an inlay is set and moisture is admitted to the inlay margins, even with a cement, film of 0.001 fine will penetrate to the very base of the cavity, due to the cement shrinking. Not true of all cements.

With silicate, moisture utterly destroys these fillings if it is admitted during the first few minutes that the filling is in place.

With amalgam it is the same story, due to moisture condensation while being triturated or placed in a wet cavity, or to moisture from handling.

We had the pleasure of listening to a lecture on amalgam by Mr. Schoonover, our chemist at the Bureau of Standards, wherein he gave an illustrated report of the tests made of saliva-mixed amalgam over a period of years.

There was mass destruction of the texture of the amalgam due to the setting up of an electrolytic current which was not detected in controls where the amalgam was builded dry. Hydrogen gas formed in those alloys containing zinc.

Amalgam has other enemies, however, one of these is sodium chloride or common salt, even in minute quantities. This is accounted for largely because of the presence of zinc in the alloy. Zinc is used to facilitate the amalgamation at time of mixing, and to assist in controlling discoloration. In many instances this zinc is in excessive amounts.

Zinc to about 0.3 acts as a scavenger at the time of melting and is largely burned out. More than the 0.3 remains as a permanent ingredient of the alloy, which augurs for better working qualities but increases expansion and augments the damage as a result of common abuses.

Our readers will do well to follow the reports of the members of the Bureau of Standards and the work of Dr. J. T. Sweeney of California, and of others interested.

We also refer you to ''Palming Amalgam.''* Souder, Beall, and Schoonover, at the National Bureau of Standards, have attempted, as time permitted, to verify these findings and present the following report:

''Clean alloy mixed in a standardized mechanical amalgamator and packed in a steel die without being touched by the hand gave the normal expected desirable expansion duing the first day, then did not change so much as 0.2 micron per centimeter during any one of the following twenty days.

''Alloy contaminated by contact with moist palm and fingers (unwashed in two hours) gave near normal expected expansion during the first day. The expansion, however, continued each day thereafter and at the end of the twelve days had reached the enormous amount of 100 microns per centimeter.

''Clean alloy amalgamated and packed as indicated above, except that a drop of saturated sodium chloride solution was added to the alloy before amalgamation, also expanded excessively, in fact almost identically in amount to that of the palmed alloy as reported above.''

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*Dental Items of Interest, p. 810, August, 1942.

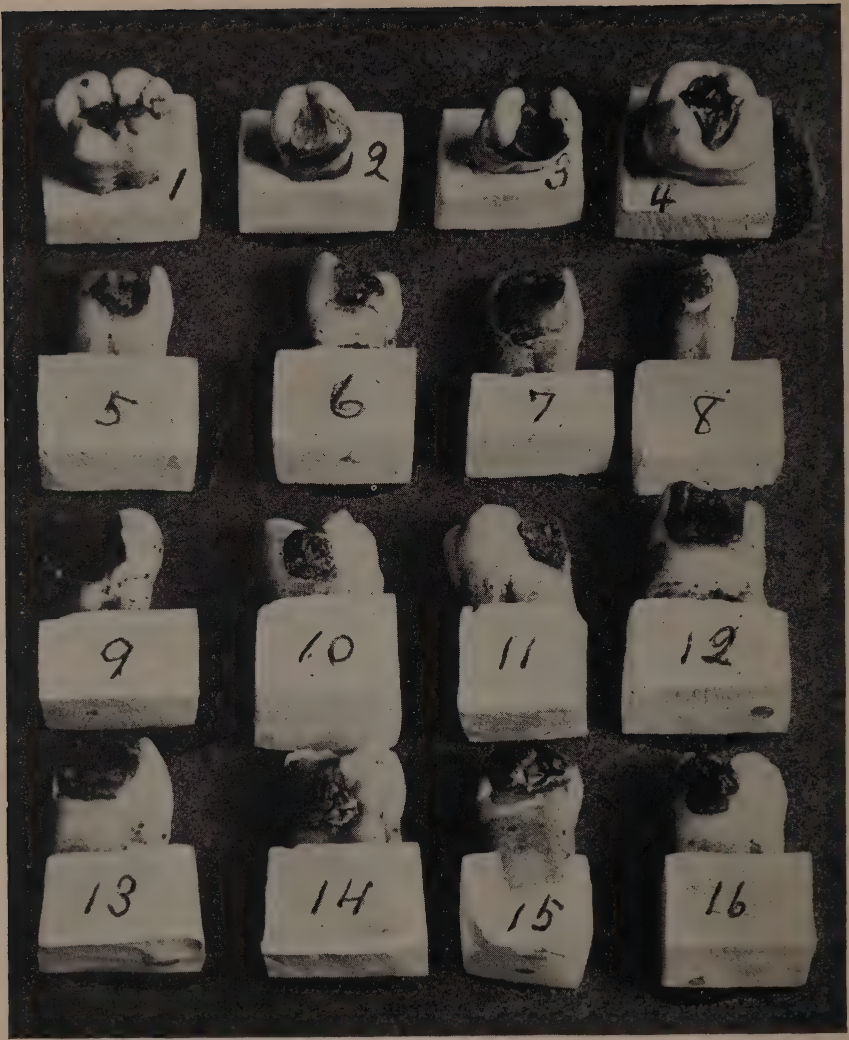

Fig. 129.—Shows a collection of old amalgam fillings, some of which were used in home practice by dentists of high repute. They failed to heed advice as to the technic for long life of amalgam fillings.

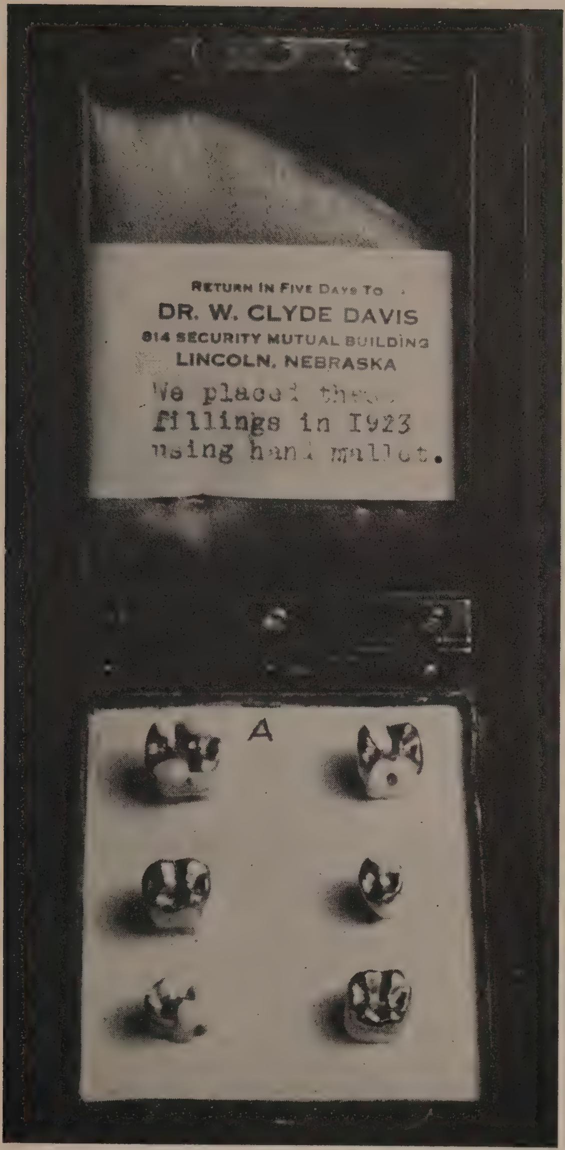

Fig. 130.—These fillings were placed in natural teeth in 1923. A mechanical mixer was used. They were packed with hand and mallet force and squeezed dry with the aim of having a 5 mercury-5 alloy end result.

Conclusions

The dentist should ask and know the zinc content of the alloy he is using, and the graduation in size of the particles in the alloy. In case he is interested in grade A amalgam fillings, he should free his practice of the known abuses. The following technic will go a long way in doing this:

Prove the alloy by some of the simple methods of research we have shown.

Learn about overmixing, undermixing, damage caused by handling, loose packing, insufficient housing, overhousing, excessive mercury in the final filling, and the effects of partial polishing.

Get a timed mechanical mixer, or heat the mortar and pestle to above the dew point. Use proportions of alloy and mercury fixed by the use of scales. Dump the resulting mix on the bracket, segregating with a steel instrument. Carry the portions to a piece of chamois skin, and with the pliers squeeze dry. Return to the bracket, and, with cotton pliers or an amalgam carrier, take to the cavity, over which a rubber dam has been placed.

The use of the first portion soft with mercury creates mercury pockets at the gingival cavosurface angle, which is later sucked back into the filling to leave ragged edges between the external line angle and the housing matrix in proximal fillings. The matrix should not be too tightly fitted on buccal and lingual margins.

As each portion is added to the cavity, the amalgam is squeezed dry and packed to place with the Malletor, which brings the excess mercury to the surface, accompanied in small part by the full formula of the alloy. This is at once removed from the cavity and more dried amalgam is added till the cavity is more than full.

The matrix housing and rubber dam are removed immediately and the filling dressed with sharp instruments to the desired external contour.

It will be noted that during the process neither hand nor finger has touched the material. It has been placed in a dried cavity and moisture has not been permitted to the cavity nor the filling until completed.

To avoid contamination with moisture from high humidity when triturating the mix, there are two ways. (1) Use the closed container, as with the Wig-L-Bug mixer. (2) For those who continue to use the mortar and pestle with hand motivation, both mortar and pestle should be slightly warmed, to raise them as well as the mixture above the dew point.

To avoid salt and moisture contamination the mix must not be touched with the fingers or hand following either method of mixing.

To further avoid moisture contamination the filling must be builded in a dry cavity, best obtained through the placing of the rubber dam.

When placing in vital, and particularly, in young teeth, the dentine should have a coat of varnish to obviate the necessity of overdesiccation.

Some of us have grown up through this evolution to try and mend our ways. Some, however, are basking in the light of yesterday's knowledge and will be asleep at the dawn of tomorrow's improvements, forgetful of the fact that knowledge enough is the beginning of ignorance.

That which follows in this chapter is taken from a paper presented at a meeting of the Institute of Metals, held on March 7 and 8, 1923, at Storey's Gate, Westminster, London, entitled "**Volume Changes Accompanying Solution, Chemical Combination, and Crystallization in Amalgams,**" by Arthur W. Gray, A.B., Ph.D. (Director of Physical Research, Caulk Dental Research Institute, Milford, Delaware, U. S. A.).

New Metallographic Hypothesis.—A brief communication to the Toronto meeting of the American Physical Society in December, 1921, outlined an hypothesis to account for the peculiar alternation of contractions and expansions that a dental amalgam undergoes during and after the process of hardening.[*] No explanation whatever appears to have been previously offered, although, with proper experimental procedure, similar phenomena might be observable whenever solidification of a substance is accompanied by solution, chemical reaction, and crystallization, especially if complicated by long-continued diffusion.

The purpose of the present paper is to elaborate the hypothesis outlined to the American Physical Society, and to illustrate its application by showing how dimensional changes observed under various alterations of influencing conditions can be accounted for. The hypothesis seems to be consistent with all facts known at present.

Metallography of Dental Amalgams.—The principal constituents of a dental amalgam alloy are silver and tin. Usually, however, other metals are present in small amounts. Of these, copper is the most important. In an alloy of the best grade it forms about 5 per cent of the whole. For the purposes of the present discussion the effects of zinc and of other modifiers can be neglected.

The classic researches of Black[†] were from the viewpoint of practical application to dentistry.

Amalgams from alloys of silver and tin only have been studied from the physicochemical point of view by McBain and his associates Joyner and Knight.[‡]

Petrenko[§] had previously investigated the silver-tin series of alloys. McBain and Joyner confirmed Petrenko's conclusion that all silver-tin alloys containing less than 75 atomic per cent of silver (73.1 per cent by mass), if well annealed, consist of crystals of Ag_3Sn embedded in an exceedingly fine granular eutectic mixture of Ag_3Sn and Sn. Upon the freezing of a molten alloy containing more than 50 per cent of silver, however, the first solid to separate from the mother liquor is a solid solution of Ag in Ag_3Sn. The pure

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[*] Gray, A. W.: The Causes of Reaction Expansions in Amalgams, Physical Review **19**: 405, 1922.

[†] Black, G. V.: An Investigation of the Physical Characters of the Human Teeth in Relation to their Diseases, and to Practical Dental Operations, Together With the Physical Characters of Filling-Materials, Dental Cosmos **37**: 353-421, 469-484, 553-571, 637-661, 737-757, 1895; The Effect of Oxidation on Cut Alloys for Dental Amalgams, ibid. **38**: 43-48, 1896; The Physical Properties of the Silver-Tin Amalgams, ibid. **38**: 965-992, 1896.

[‡] Joyner, R. A.: Amalgams Containing Silver and Tin, Tr. Chemical Society, **99**: 195-208, 1911; McBain, J. W., and Joyner, R. A.; Amalgams Containing Tin, Silver, and Mercury, Dental Cosmos **54**: 641-650, 1912; Knight, W. A., and Joyner, R. A.: Amalgams Containing Silver and Tin, Tr. Chemical Society **103**: 2247-2262, 1913; Knight, W. A.: The Ageing of Alloys of Silver and Tin, Tr. Chemical Society **105**: 639-645, 1914; McBain, J. W., and Knight, W. A.: Report on the Chemical Constitution and Physico-Chemical Properties of Dental Amalgams, Sixth International Dental Congress, London, 1914, Section IV, Dental Cosmos **57**: 630-639, 1915.

[§] Petrenko, G. J.: Ueber die Legierungen des Silbers mit Blei und Zinn, Ztschr. f. anorganische Chemie **53**: 200-211, 1917.

Ag_3Sn is stable only below 480° C., so that, if cooling is not very slow, some of this solid solution is retained in the cast ingot.

McBain and Joyner's investigations led them also to the conclusion that the process of amalgamation consists in a chemical reaction of the mercury with the compound Ag_3Sn to form the compound Ag_3Hg_4 *(arbor Dianæ)* and free tin according to the equation:

$$Ag_3Sn + 4Hg \rightarrow Ag_3Hg_4 + Sn$$

If more mercury is used than sufficient to combine with all the silver present in the alloy, the excess produces a solid solution of mercury in tin, which forms soft hexagonal crystals. Since this solution becomes saturated when the mercury content reaches 1 per cent or so, further excess remains as a liquid containing at room temperature less than 1 per cent of tin.

The equation expressing the reaction between Ag_3Sn and Hg may, of course, represent only the initial and the final stages of amalgamation. This possibility was recognized by McBain and Knight, who remarked that an intermediate stage might exist, for example, formation of Ag_3Hg_2.

Contractions and Expansions Following Amalgamation.—McBain and Knight show that the amalgamation of Ag_3Sn is accompanied by a considerable contraction. From specific volume data they calculated that when freshly cut filings of Ag_3Sn are amalgamated with just sufficient mercury to combine with all the silver, the final volume of the amalgam formed is nearly 5 per cent less than the total volume of the Ag_3Sn and the Hg before amalgamation. Their dilatometric measurements tended to confirm these calculations.*

In pointing out that the only part of this enormous volume change that is of practical importance in the making of a tooth filling is the part that takes place after the amalgam is packed into the cavity, McBain and Knight assert that every case occurring in dental practice must be intermediate between no volume change and the extreme changes indicated in the tables exhibiting the results of their calculations, thus implying that an amalgam tooth filling always contracts.

This implication is, however, contrary to the universal observation of those who have measured the dimensional changes of dental amalgams during hardening. Depending upon composition or physical treatment, or both, some amalgams shrink badly; others expand.

The dimensional changes that occur during the hardening of a dental amalgam are of such importance in connection with the tooth-restoring properties of this valuable filling material that determinations of these changes are nearly always included in tests of amalgam alloys. A contracting amalgam may shrink sufficiently to admit oral fluids and bacteria between the filling and the cavity walls; an expanding amalgam may swell sufficiently to extend above the margins of the cavity, or even to split the tooth. The ideal amalgam expands just enough to make sure that a properly inserted filling will remain firmly in contact with the tooth.

Most investigators of dental amalgams have confined their attention to the volume changes that occur during and after hardening. Apparently they have completely overlooked the main change that accompanies solution and combination. Even in the changes they investigated, they missed many details because they used unsuitable apparatus and failed to control influencing conditions.

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*Similar calculations had been made by A. Fenchel: Dental Cosmos 52: 30, 1910. Some of Fenchel's assumptions in regard to the reactions involved are questionable.

On the other hand, McBain and Knight, as well as Fenchel, confined their attention to the net result of the various volume changes that occur when silver-tin alloys are amalgamated. They failed, therefore, to note the details of the process. They missed the intermediate expansions and contractions that are of particular concern to the dentist. Since they all refer to Dr. Black's epoch-making work, it is remarkable that they should have ignored the changes that he described.

All investigators up to the present time have treated expansions and contractions in dental amalgams as if they were unrelated, though coexisting, actions. The prevailing belief is that silver causes expansion and tin contraction. Black's procedure of so adjusting the composition of a dental alloy that its amalgam will show a desirable small reaction expansion is, therefore, regarded as ''balancing'' the opposing tendencies of the component metals.

This belief is the natural outcome of Black's discovery that, other things being equal, the expansion observed in silver-tin amalgams after they are tightly packed into a cavity increases regularly as the silver-content is progressively increased, while the contraction increases with increase in the tin-content. Most dental writers and manufacturers of dental alloys seem to have overlooked the fact that the amalgamation of silver is accompanied by a large contraction, and the amalgamation of tin by a smaller, but considerable expansion, although both of these facts have been pointed out in a widely circulated American dental journal.[*]

No one seems to have realized that the amalgamation of the silver might be responsible for most of the contraction as well as for most of the expansion, the tin acting mainly as a diluent. How this new conception fits in with a reasonable interpretation of observed phenomena will now be elucidated.

Typical Curve of Reaction Expansion.—Black had observed that some amalgams contracted a little before they expanded.[†]

After studying curves representing reaction expansions of various dental amalgams under widely differing conditions, I discovered that every individual curve could be regarded as a special case of a more general curve. This general curve, which I have designated as the typical curve of reaction expansion, is characterized by the following four consecutive stages of alternate contraction and expansion:

1. Rapid contraction to a minimum.
2. Somewhat slower expansion to a maximum.
3. Considerably slower contraction to a second minimum.
4. Very much slower expansion to a second maximum.

One or more of these stages can be masked or can be accentuated by mechanical treatment of the amalgam.[‡]

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[*] By Fenchel and by McBain and Knight, Dental Cosmos, *loc. cit.*

[†] Black, G. V.: The Physical Properties of the Silver-Tin Amalgams, Dental Cosmos **38**: 982, 1896.

[‡] Gray, A. W.: Metallographic Phenomena Observed in Amalgams, Tr. Am. Inst. Mining and Metallurgical Engineers **60**: 684, 693, 1919, J. Nat. D. A., **6**: 913, 918, 1919; Oral Topics **2**: 24, 33, London, 1922. Also, Contractions and Expansions of Amalgams With Time, Physical Review **18**: 108, 1921, J. Nat. D. A. **19**: 324, 1922.

The reaction expansions of more than five hundred amalgam specimens have now been measured under accurately controlled conditions that have been systematically varied. Some specimens have been observed at regular intervals for about two years. In every case the expansion curve was found to conform to the behavior outlined above. Many examples were obtained that show all four stages in the same curve. Some will be described later in this paper.

Explanation of the Typical Curve.—The work of McBain, Joyner, and Knight, supplemented by my own observations, and by physicochemical facts of common knowledge, leads to a simple explanation of the phenomenon.

The rapid drop to a minimum that forms the first part of the typical curve of reaction expansion evidently represents the end of the stage dominated by contraction accompanying solution of the alloy in mercury and formation of compounds with silver and copper.

Crystallization of these mercury compounds quickly follows their formation, and is accompanied by expansion. The first minimum in the curve marks the time when the rapidity of this expansion just equals the rapidity of the contraction caused by the simultaneous formation of more of these same compounds.

As the solution and the reaction diminish, the crystallization expansion comes to predominate. This predominance is indicated by the rise of the curve from the first minimum to the first maximum.

The mixing of the alloy with the mercury, whether by trituration or otherwise, reduces the alloy to particles of microscopic size. Many of these particles must, however, be considerably larger than molecules at the time the amalgam is molded into a test specimen. Consequently, there will be a gradual inward diffusion of the free mercury coating the alloy particles, resulting in still more solution, reaction, and crystallization, which may continue long after the amalgam has beegun to harden. The volume changes resulting from this diffusion might easily account for the slow descent of the typical reaction expansion curve after reaching the first maximum, and for the very much slower rise that follows.

The gradual changes in shape that the reaction expansion curve can be made to undergo by systematic variation of influencing conditions are exactly what might reasonably be expected if the foregoing hypothesis is correct. Illustrations of such changes are given later in this paper as well as elsewhere.*

The slow growth of the crystals during the hardening of a dental amalgam is beautifully shown by a series of eight photomicrographs taken at intervals during the first day and published by Fenchel.†

In many of my reaction expansion curves, slight subsidiary maxima and minima appeared. Since the deviation from the general course of a curve seldom amounted to more than a fraction of a micron, I was at first inclined to ascribe such undulations to vagaries in the measuring apparatus; but they have persisted with such regularity that it is difficult to believe that they are not caused by real dimensional changes. Deviations of this kind can be seen in Figs. 145 to

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*Gray, A. W.: *loc. cit.*

†Fenchel, A.: Some New Researches into Amalgams, and their Significance for Dentists, Dental Cosmos 1: pp. 553-572, Figs. 17-24, pp. 566-569, 1908.

151, inclusive. Perhaps they are caused by reaction of the mercury with the copper in the alloy. Additions of this metal to a silver-tin alloy are accompanied by large increases of the expansion observable during the hardening of the amalgams. It is not to be expected that copper and silver will react with mercury at the same rate. Differences in reaction rate would be marked in the composite expansion curve by relative displacements of the maxima and the minima attributable to the separate actions of the component metals.

Factors That Influence Dimensional Changes

General Principles.—Any procedure that brings about more intimate contact of mercury and alloy will facilitate diffusion, solution, and combination. Reaction in a dental amalgam should, therefore, be accelerated by fine comminution of the alloy, by increasing the effectiveness of the amalgamation procedure, by tight packing into tooth cavity or mold, and by suitable temperature during hardening.

Increase in the average rate of reaction causes each characteristic of the expansion curve to appear earlier and to disappear earlier. Consequently, it causes quicker attainment of a stable volume. Conditions that hasten reaction at the beginning may, however, retard it later, and thus actually delay attainment of stability. For example, either insufficient or excessive amalgamation may result in large, long-continued volume changes, some of which may not become conspicuous until after several days.

Increase of solution and combination before packing is completed leaves less reaction to proceed afterward. Although this must reduce the *actual* contraction during hardening, it may increase the contraction *observable* by measurements of dimensional changes. How some of the contraction escapes measurement will be explained presently.

Crystallization occurring before packing leaves less crystallization to produce expansion later. One result of this will be a less prominent first maximum in the curve of reaction expansion. Frequently the only suggestion of this maximum is an inconspicuous temporary reduction in curvature during the first few hours. Often the first and the second minimum merge into each other so completely that not even the slightest trace of an intervening maximum is discernible.

The finer the particles into which a dental alloy is cut, the more rapidly will they amalgamate if their surfaces are clean. Increase of alloy surface brought into contact with the mercury, like increase in the solubility produced by changing crystalline Ag_3Sn into amorphous,* accelerates solution and combination. The quicker elimination of the liquid mercury-tin solution that serves to lubricate the mix makes necessary a greater mercury-alloy ratio in order to obtain proper plasticity. Also, fine particles of alloy unite with a greater proportion of mercury during mixing; coarse ones unite with less. Therefore, the fine particles retain more mercury after the excess is squeezed out during packing.

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*Gray, A. W.: "Metallographic Phenomena Observed in Amalgams," Section 22.

The more thorough the mixing of mercury and alloy, the faster the reaction between them. Some methods are more effective than others. Trituration with mortar and pestle is superior to kneading in the hand—and more sanitary. A good mechanical mixer acts more rapidly than any hand-mixing procedure. Increasing the mercury-alloy ratio enough to yield a smooth, plastic mix starts solution more promptly by facilitating the wetting of the alloy particles with the mercury. Prolonging the time of mixing accomplishes more reaction before the amalgam is packed, leaving less to take place during hardening.

Effects of changing amalgamation variables may, of course, be further emphasized by suitably changing several variables simultaneously. Early rise toward the second maximum of the expansion curve can thus be brought about.*

Manipulation of an amalgam during the act of packing it into a tooth cavity is equivalent to prolonging trituration. Removal of soft material brought to the surface prevents retention of a deleterious excess of mercury and hastens completion of the hardening process.

Increase of packing pressure results in squeezing out of the tooth filling or cast more of the mechanically retained mercury, which carries out with it a little dissolved tin and other metals together with some fine particles of undissolved alloy and of solidified amalgam. Removal of this material must reduce the amount of subsequent reaction in the filling, and must, therefore, lessen the magnitude of the accompanying volume changes. In addition, the more intimate contact between mercury and alloy that is effected by tight packing hastens the attainment of stability, because it increases the rate of reaction during hardening. Tight packing also reduces porosity of the amalgam and secures closer fitting of the filling to the cavity walls. As might be expected, the influence of a given change in packing pressure becomes rapidly less as the pressure is increased.

Temperature reduction hinders diffusion, solution, and combination. It may retard or it may accelerate crystallization. If the temperature is low enough, reduction in fluidity caused by further cooling may so augment the resistance to crystal growth that the increased tendency to form crystallization nuclei will be overcome.

If a dental amalgam after hardening in the ordinary way is softened by heating, and is then packed into a mold until it rehardens upon cooling, it will rapidly expand for hours after it is removed from the mold.* This expansion is easily explainable. Heating melts the amalgam crystals. Besides, it facilitates union of any silver and mercury that previously may have remained uncombined in the amalgam. This eliminates combination, with accompanying contraction, during rehardening, which must consist primarily in recrystallization accompanied by expansion.

Softening an amalgam by heat also gives opportunity for eliminating voids resulting from the combination of silver and mercury while the amalgam was hardening after preparation by mixing alloy and mercury.

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*See curve of specimen R 39 in Fig. 37 of Gray, A. W.: "Metallographic Phenomena Observed in Amalgams."

Abnormally large and rapid expansion occurs in a specimen molded from amalgam prepared by triturating more mercury with fillings from a hardened dental amalgam.*

The second trituration breaks up the hard crystals into minute fragments; but since these are already saturated with mercury, the addition of more does not soften them. Consequently, they resist the contraction that accompanies the formation of more compounds after molding is completed, but they are pushed apart during recrystallization about themselves as nuclei. Moreover, the contraction resulting from formation of additional compounds during retrituration will occur before molding; but much of the expansion accompanying the crystallization of these compounds will take place while the test specimen is under observation in the dilatometer.

The exothermic nature of the reaction constituting amalgamation should be familiar to every investigator of dental amalgams. Ordinarily the temperature rise from the heat of reaction is so small that it escapes notice unless looked for, but with some commercial dental alloys, and especially with some experimental alloys, it is distinctly perceptible. Warming from the reaction, from the work done during amalgamation, and by conduction from the hand of the operator, would all cause some thermal expansion of the amalgam. If cooling then occurred during the measurement of reaction expansion, the accompanying thermal contraction would, of course, form part of the effect observed.

An amalgam evolving heat while hardening would maintain itself at a gradually lessening temperature above its surroundings. In an air bath, especially if unstirred, the temperature difference might easily be some degrees centigrade; but when immersed in a stirred liquid, the average temperature of a small amalgam cylinder could hardly be enough higher than that of the liquid to account for much of the initial contraction often observed. By far the most of this initial contraction is more naturally accounted for by assuming that it is the last of the large contraction that we know accompanies combination of silver and mercury to form such compounds as Ag_3Hg_2 or Ag_3Hg_4.

Even thorough trituration with mortar and pestle leaves many undissolved grains of alloy in the amalgam, although these grains may be so small as to escape detection by eye or by feel. Coarse comminution of alloy, deficient amalgamation procedure, loose packing, and low temperature all facilitate long-continued diffusion of mercury into the interiors of the undissolved grains, and, consequently, long-continued changes of volume. As far as each individual grain is concerned, the net result must be contraction; but the effect observed when dimensional changes are measured may be expansion.

The reason for this apparent inconsistency is easily found. Each grain touches its neighbors in only a few places. Reaction with the adhering mercury occurs mainly on the surfaces that are not protected by contact with adjacent grains. This leaves a core of hard alloy connecting contact regions until the last to be attacked by the inwardly diffusing mercury. The stiff skeleton built up of the connecting cores resists contraction; and the lower the tin content of the alloy the greater will be the resistance. The contraction accompanying reaction must, therefore, result in the formation of voids in places formerly occupied by the soft mercury-tin solutions that surrounded the original hard grains. The cored skeleton will become stiffened, and enlarged near contact regions, by accretions of surrounding material. Crystal growth following combination will not be greatly opposed by the skeleton framework thus formed, which, consequently, will expand in all directions. Growth perpendicular to lines joining two regions of contact between a grain and its neighbors will merely project crystals into adjacent voids; but growth along such lines will lengthen the elements of the amalgam framework and cause enlargement of the entire structure.

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*See curve of specimen R 40 in the figure last cited.

It is easy to see how large grains of alloy will facilitate a procedure such as that just sketched, and will, therefore, tend to yield expanding amalgams. But expansion obtained by coarsely cutting a dental alloy results not only in an amalgam that is difficult to pack closely to the walls of a tooth cavity, but in one that is permeated by large pores and countless cracks.*

How Tin in Alloy Facilitates Contraction.—Since the expansion accompanying crystallization is much smaller than the contraction observable as the net result of the volume changes accompanying solution and combination, any procedure that facilitates continuance of solution and combination after an amalgam is packed into a tooth cavity or molded into a test specimen, will increase the proportion that contracts during hardening and will thereby mask more of the expansion. It may even conceal the expansion entirely.

Increasing the tin content of an amalgam alloy aids in prolonging solution and combination. To a large extent the tin will act as a diluent, interfering with the combination of the silver and the mercury during the amalgamation before packing into the tooth or the mold. While this amalgamation is in progress, considerable mercury must become held by the tin—some in solution and some mechanically. Much of this mercury remains in the filling even after all attempts have been made to remove it, either before or during packing. Slowly it diffuses to unattacked Ag_3Sn crystals and combines with the silver, causing more contraction than expansion.

Another element may enter here to increase the contraction. According to Fenchel, formation of the solid solution of mercury in tin is accompanied by a volume increase of about 1.5 per cent.† If this be true, there will be a corresponding contraction during hardening while the dissolved mercury diffuses from the tin into the silver.

The retarding effect of excess tin on the reactions that accompany amalgamation is shown by the well-known fact that amalgams from tin-rich alloys harden much more slowly than amalgams from silver-rich alloys. The presence of the mechanically retained liquid solution of tin in mercury, and of the soft solid solution of mercury in tin, account for the long-continued plasticity of amalgams from low-silver dental alloys, which for this reason are called *slowly setting alloys* to distinguish them from the *rapidly setting alloys* of high silver content.[*]

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*See pages 238 and 244.

†Desch, "Metallography," 1913, p. 234, and Giua, "Chemical Combination Among Metals," 1918, p. 55, quote Maey as having found a contraction of 0.9 per cent. Maey's original papers are not accessible to me as I write, but my own measurements of reaction expansions in pure tin amalgams indicate expansion. For a description of these measurements see page 227.

Although a given mass of a low-silver alloy requires less mercury for easy amalgamation and retains less under given packing conditions than an equal mass of a high-silver alloy, there is more danger of the former's retaining too much for the silver available. The larger proportion of mercury retained by the high-silver alloy is advantageously used to form more Ag_3Hg_4, resulting not only in a harder, stronger, and less deformable amalgam, but also in a greater volume from the same mass of alloy.

That excessive contraction during the hardening of a tin-rich dental amalgam can be materially reduced by removal of softened material brought to the surface during packing in a cavity has been well shown by Black.[†]

"Aging" of a Comminuted Silver-Tin Alloy.—Annealing ("aging") a comminuted silver-tin alloy also reduces the rate at which it will react with mercury. McBain, Joyner, and Knight, after many carefully conducted experiments in attempts to discover the causes of phenomena observable upon "aging" silver-tin alloys, conclude that aging "is a property solely of the compound Ag_3Sn contained in the alloys; it retards the initial stages of amalgamation, but does not affect the final products."

Although they conclude also that aging is not "a case of annealing after mechanical strain," I believe that it does consist partly in recrystallization of amorphous or colloidal material produced by severe deformation of Ag_3Sn crystals during comminution.[‡]

One natural result of changing some of the Ag_3Sn from the crystalline to the amorphous state would be an increase in solubility.[§] This would cause a freshly cut silver-tin alloy to require more mercury for making an amalgam of workable plasticity. The quicker absorption of the mercury would result in faster reactions. Therefore, after maintaining a given amalgamating procedure for a given time, more mercury would be locked up with the silver so that it could not be expressed from the amalgam by squeezing through a cloth or by tight packing into a cavity. The amalgam would also harden faster and consequently be more difficult to pack. It would shrink less and expand more after packing, because the combining of the mercury and the silver, with the accompanying contraction, would have progressed further before packing could be completed; while the crystallization, interfered with by the trituration or other mixing procedure, and by the presence of the mechanically retained liquid solution of tin in mercury, would not be greatly accelerated. Consequently, less of the expansion accompanying crystallization would be masked by the contraction accompanying solution and combination, in spite of the fact that ''aged'' Ag_3Sn has a specific volume about 0.4 per cent smaller than that of freshly cut Ag_3Sn, so that the net contraction resulting from amalgamation is greater with a freshly cut than with an ''aged'' silver-tin alloy.*

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[*] The low crushing strength observable in fully hardened amalgams from tin-rich alloys, and the pronounced plastic deformation (flow) under a small load maintained for some time, are perhaps attributable partly to one or both of these mercury-tin solutions, especially when more mercury has been retained than sufficient to combine with all the silver present; but they seem attributable mainly to the large proportion of the easily deformable tin insufficiently stiffened by the Ag_2Hg_4. Because tin-rich alloys yield easily deformable amalgams they are frequently called *plastic alloys.* The combination of undesirable properties that render such alloys unfit for making satisfactory tooth restorations has caused them to be designated as *low-grade alloys.*

[†] Dental Cosmos 37: 648-650, 1895, Alloys Nos. 4, 5, and 10.

[‡] A discussion of my reasons for this belief must be reserved for another paper. For the present it will suffice to point out that the annealing phenomena characteristic of silver-tin alloys would be a natural, although not a necessary, consequence of converting amorphous into crystalline material: or, approaching the phenomena from the opposite point of view by considering the crystalline structure as the normal one, the changes observable upon amalgamating freshly comminuted alloys are just what might reasonably be expected if the proportion of amorphous Ag_3Sn should be appreciably increased by deformation during comminution.

[§] By "amorphous" or "colloidal" material I mean merely material consisting of very small irregularly arranged particles, whether these particles themselves have or have not a regular (crystalline) structure.

Freshly cut and annealed dental alloys show just such differences as are discussed in the foregoing paragraphs.

Contamination by surface films of oxide, sulfide, or other impurities that interfere with amalgamation, and thereby reduce the reaction rate, probably plays some part in masking crystallization expansion. Black's discovery that ''aging'' of a comminuted silver-tin alloy is produced, not by surface contamination, but by heat treatment, has possibly led some manufacturers of high-silver dental alloys that yield contracting amalgams, to the belief that protection from the air during annealing is an unnecessary precaution.

Experimental Data Illustrating Hypothesis

The foregoing sections have shown how a simple general hypothesis of reaction expansions can explain the particular dimensional changes that have been observed in dental amalgams. Detailed accounts of experiments were omitted from the exposition in order to avoid obscuring general principles. Examples illustrating the application of these principles have already been published.† Additional examples will now be presented.

Reaction Expansion of Tin Amalgam.—The dilatometric behavior of tin amalgam is of interest because it upsets the long-standing current belief that tin is the contracting element in a dental amalgam.

My measurements were made with the same method and apparatus that I have used for the past six years in determining the reaction expansions of dental amalgams.‡ Each test cylinder was prepared from 3 Gm. filings of pure tin and 4.50 Gm. mercury triturated two minutes in a glass mortar, and then condensed under a measured pressure applied two minutes to the piston of the steel mold, which was at approximately 37.5° C. Expansion measurements were started within two or three minutes after the cylinder was molded. During observations the stirred oil bath of the dilatometer was maintained at 37.5° C. ±0.01° C.

Table I shows for each cylinder the relation between mercury content (in per cent) and packing pressure (in kilogram weight per circular centimeter). Apparently most of the mercury must have been mechanically retained, since tin will dissolve only about 1 per cent of mercury at room temperature.*

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*Knight: Tr. Chem. Soc. 105: 643, 1914. McBain and Knight, Sixth Internatl. Dental Congress, 1914: Dental Cosmos 57: 635-637, 1914.

†Gray, A. W.: *loc. cit.*

‡Gray, A. W.: "Metallographic Phenomena Observed in Amalgams," Part II.

TABLE I

MERCURY CONTENTS OF TIN AMALGAMS

SPECIMEN NUMBER	PACKING PRESSURE IN KG. PER CIR. CM.	PER CENT MERCURY	DEVIATIONS FROM AVERAGE
R 515	100	21.4	----
R 511	400	19.6	-0.3
R 512	400	19.8	-0.1
R 513	400	20.3	+0.4
Average	400	19.9	±0.3
R 514	1600	19.0	----

Fig. 131 represents the results of my first attempt to measure the reaction expansion of a tin amalgam. It is instructive in showing how cautious one must be when interpreting the readings of a measuring instrument. The heavy line forming the beginning of the plot follows 370 observations taken at one-minute intervals during the first 6.4 hours immediately following the completion of the cylinder. The dashes cover time intervals during which no observations were made. When the cylinder was removed from the dilatometer, it was found that the pressure of the measuring contacts, although so light that they could be lifted by a small camel's-hair brush, had nevertheless been sufficient to press easily noticeable grooves into the surface of the amalgam. Gradual hardening is shown by the changes in slope of the heavy lines that mark the observations. The abrupt changes in direction where solid and dashed lines join is ascribable, at least partly, to our regular practice of eliminating frictional lag by gently tapping the dilatometer with blows from the hammer of a vibrating electric bell before taking a reading. The shaking of the contacts undoubtedly caused them to sink into the amalgam faster than during the intervals when no observations were made.

Fig. 132 represents results obtained with three cylinders of tin amalgam when precautions were taken to eliminate the errors caused by the sinking in of the contacts. Several observations were rapidly taken while the contacts were closed upon the specimen. These observations showed a steady approach of the contacts, which would ordinarily be interpreted as contraction of the amalgam. Then the contacts were lifted, and the specimen was left free from constraint for some minutes. More observations again indicated an approach of the measuring contacts, but comparison of the last reading of the first series with the first reading of the second showed that the diameter of the cylinder had increased during the interval. The curves shown in Fig. 132 were obtained

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*van Heteren, W. J.: "Die Zinnamalgame," *Ztschr. f. anorganische Chemie* 42: 129-173, 1904.

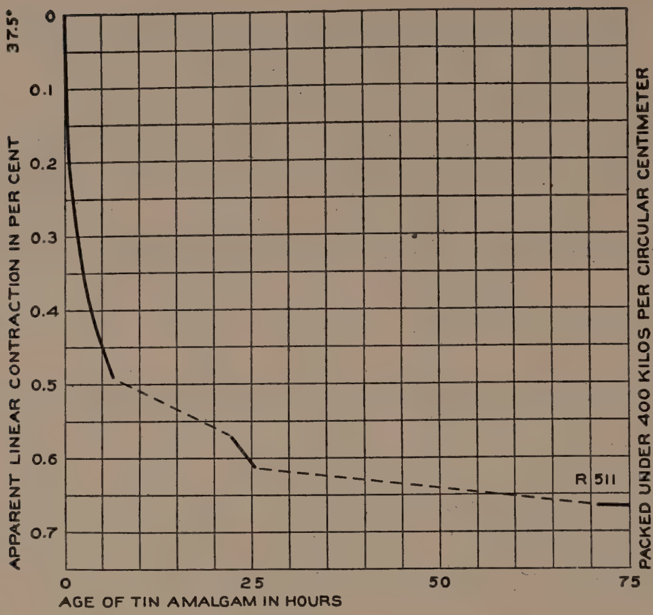

Fig. 131.—Apparent contraction of tin amalgam. An effect of flow under very light pressure. Gradual hardening shown by changes in slope of solid lines.

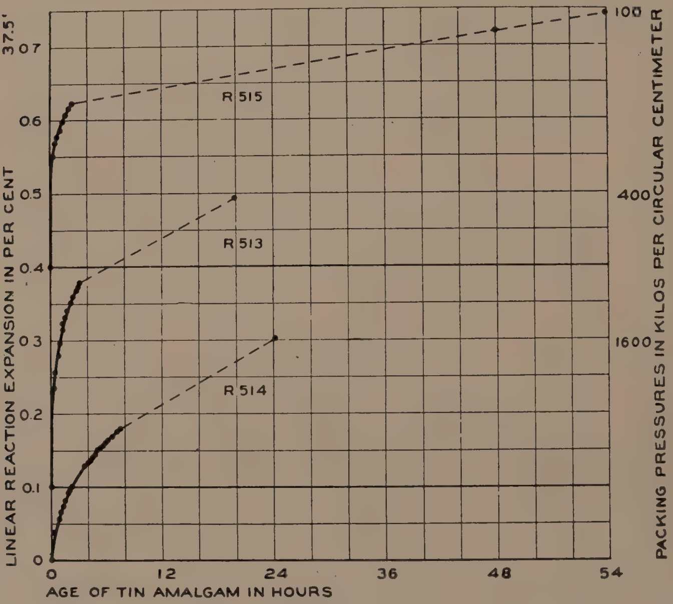

Fig. 132.—Tin amalgam expands while hardening.

by piecing together expansion elements yielded by repetitions of this procedure. The dots represent the actual observations.

Although some of the expansions recorded by Fig. 132 may be caused by the growth of individual crystals immediately under the measuring contacts, the regularity of the curves suggests that the indications of the dilatometer correspond to growth of the entire cylinder of amalgam.

The growth of crystals on an end surface of specimen R 515 is shown in Fig. 134, p. 232. The magnification is 25 diameters.

Effects of Changing Amalgamation Variables.—In my paper entitled "Metallographic Phenomena Observed in Amalgams," several charts were presented to show how variations in thoroughness of amalgamation cause large differences in the reaction expansions of dental amalgams prepared from the same batch of alloy. An expansion or a contraction could be produced at will by merely changing the manipulation.

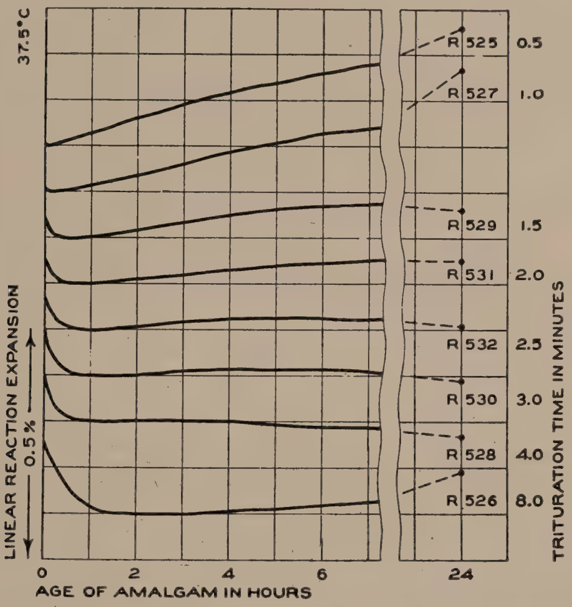

Fig. 133.—Reaction expansion of a dental amalgam is changed by varying time amalgam is triturated. Expansions of some specimens during 6.5 months are described in Table II.

An unusually good exhibition of effects produced by prolonging trituration is afforded by the reaction expansion curves assembled in Fig. 133 and by the data on the same specimens assembled in Table II. The results presented here show how the expansion curve is gradually changed. They show also examples of the same specimen yielding both minima and both maxima of the typical curve of reaction expansion.*

The amalgams represented were made from a dental alloy of the highest grade. Each test cylinder was made from a 3 Gm. sample triturated by mortar

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*See page 230.

Table II

Effects of Varying Trituration Time

TRITURATED 0.5 MINUTE. SPECIMEN R 525

1st Minimum	Reached as soon as molded
1st Maximum	+0.30 per cent diameter change in 2 weeks
	+0.02 per cent additional change during next 2 months. No observable change during following 4 months, when measurements were discontinued
Total Change	+0.32 per cent in 6.5 months

TRITURATED 1.0 MINUTE. SPECIMEN R 527

1st Minimum	-0.002 per cent reached in 10 minutes
1st Maximum	+0.33 per cent in 10 days
	+0.15 per cent more by end of 6.5 months
Total Change	+0.48 per cent in 6.5 months

TRITURATED 1.5 MINUTE. SPECIMEN R 529

1st Minimum	-0.03 per cent in 0.5 hour
1st Maximum	+0.07 per cent during next 7 hours. Reached maximum during night. Change not observed.
2nd Minimum	-0.01 per cent during 16 hours. Changed less than ±0.01 per cent for a month. Thereafter, slow expansion
2nd Maximum	+0.05 per cent in 5.2 months
Total Change	+0.08 per cent in 6.2 months

TRITURATED 2.0 MINUTES. SPECIMEN R 531

1st Minimum	-0.05 per cent in 0.5 hour
1st Maximum	+0.05 per cent at end of 7.5 hours. No change observed following morning
2nd Minimum	-0.03 per cent during first month
2nd Maximum	+0.02 per cent during second month. No change during next 2 months
Total Change	-0.01 per cent in 4 months. Accident stopped observations during very slow expansion*

TRITURATED 2.5 MINUTES. SPECIMEN R 532

1st Minimum	-0.07 per cent in 0.5 hour
1st Maximum	+0.025 per cent during next 4 hours
2nd Minimum	-0.04 per cent during next month
2nd Maximum	+0.06 per cent during next 5 months
Total Change	-0.02 per cent in 6.2 months

TRITURATED 3.0 MINUTES. SPECIMEN R 530

1st Minimum	-0.10 per cent in 1.0 hour
1st Maximum	+0.01 per cent during next 3.5 hours
2nd Minimum	-0.03 per cent during night. No further change observable for more than 1.5 months
2nd Maximum	+0.05 per cent during following 4.5 months
Total Change	-0.07 per cent in 6.2 months

TRITURATED 4 MINUTES. SPECIMEN R 528

1st Minimum	-0.10 per cent in 1.0 hour
1st Maximum	+0.005 per cent during next 1.5 hours
2nd Minimum	-0.05 per cent during next few days
2nd Maximum	+0.14 per cent during next 6 months
Total Change	-0.005 per cent in 6.3 months

TRITURATED 8 MINUTES. SPECIMEN R 526

1st Minimum	-0.16 per cent in 2 hours
1st Maximum	Obliterated by excessive trituration
2nd Minimum	Practically coincides with first minimum and first maximum
2nd Maximum	+0.30 per cent during 6.4 months, expanding rapidly at first, then slowly. Apparently still growing when measurements were discontinued +0.14 per cent in 6.4 months
Total Change	

*Another test specimen, similarly prepared some months earlier from the same alloy, contracted no more than 0.01 per cent during the first three months after it was one day old. When a year old, it had expanded only 0.04 per cent beyond this second minimum.

and pestle with 1.60 times this mass of mercury; and each was packed under a pressure of 25 kg. per cir. cm. maintained for two minutes.

Reasons are given in Table II for effects of the kind produced by prolonging trituration. By increasing the proportion of mercury and silver combined before packing begins, less solution and combination are left to proceed after packing. This must lessen the *actual* contraction during hardening, although the contraction *observable* by measurements of dimensional changes may be considerably increased. The reasons for this apparent contradiction are similar to those presented in showing why coarsely cut alloys tend to yield amalgams that expand during hardening. An additional reason is that since more mercury compounds are formed during mixing, more also crystallize then, although the continued agitation and the presence of excess mercury prevent the growth of crystallites into crystals large enough to be noticed unless the mixing time is unduly prolonged. Crystallization that occurs during the process of mixing and packing, by lessening the crystallization available to produce expansion soon after the test cylinder is completed, would naturally result in a less conspicuous first maximum of the expansion curve. Fig. 133 and Table II show clearly how progressive increases in trituration time gradually reduce and finally obliterate this maximum. Specimen R 526, triturated eight minutes, shows how excessive trituration results in a considerable initial contraction that is soon followed by a much larger, long-continued expansion.

The lesson that the dentist should learn from these effects of varying the trituration time is to avoid both the extreme of too little trituration advocated by some, and the extreme of too much trituration advocated by others. Both extremes result not only in undesirable volume changes, but also in structural weakness from crevices and other voids. Too little trituration, as well as too little mercury, produces voids by shrinkage following diffusion and combination, as explained in the portions of Figs. 134 to 137 that show how a coarsely cut alloy may produce expansion of the amalgam as a whole, but contraction around the individual grains. Excessive trituration permits crystallization to reduce the plasticity of the amalgam seriously. This favors the formation of folds that are similar to ''cold shuts'' in castings. Loss of strength and difficulty in making the filling fit close to the cavity walls are the natural consequences. Somewhat similar results follow the use of too little mercury or too little trituration—in other words, insufficient amalgamation.

Structural differences produced by differences in amalgamation are shown by Figs. 134, 135, 136, and 137, which picture characteristic areas on the ends of amalgam cylinders 6 mm. in diameter, each of which was made from 2 Gm. of the same high-grade dental alloy packed in the same mold and under the same pressure. The low pressure of 25 kg. per circular centimeter was chosen in order to make the test sufficiently sensitive to reveal defects in even the best amalgam. The magnification is 25 diameters. Fig. 138 shows perspective views of the same cylinders magnified 4 diameters.

In making cylinder S 5584, equal masses of alloy and mercury (i.e., the mercury-alloy ratio was 1) were triturated together 2.5 minutes. The other

Surfaces of molded amalgams after hardening, ×25. Oblique illumination.

Fig. 134.

Fig. 135.

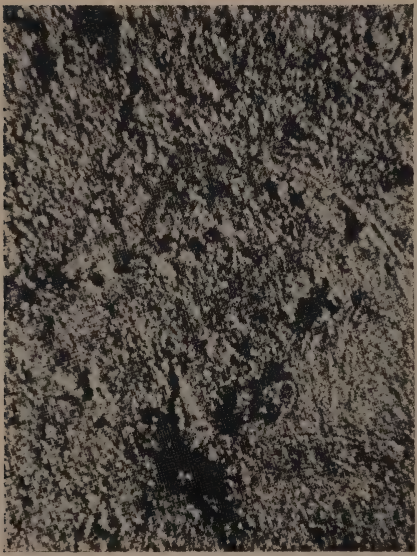

Fig. 136.

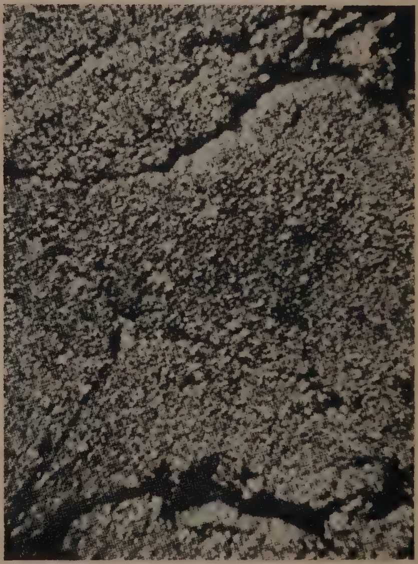

Fig. 137.

Fig. 134.—Tin amalgam molded under 100 kg. per cir. cm.

Fig. 135.—Too little mercury used in mixing this dental amalgam. Difficult to amalgamate. Weakened by cracks and coarse structure. S 5584, Fig. 138.

Fig. 136.—Too little trituration. Imperfect amalgamation. Coarse-grained amalgam. S 5578, Fig. 138.

Fig. 137.—Too much trituration. Fine-grained amalgam, but cracks and folds from excessive crystallization before packing. S 5579, Fig. 138. [Gray.]

three cylinders were all made with the mercury-alloy ratio of 1.60; but the trituration times were 0.5, 2.5, and 8.0 minutes for S 5578, S 5580, and S 5579, respectively.

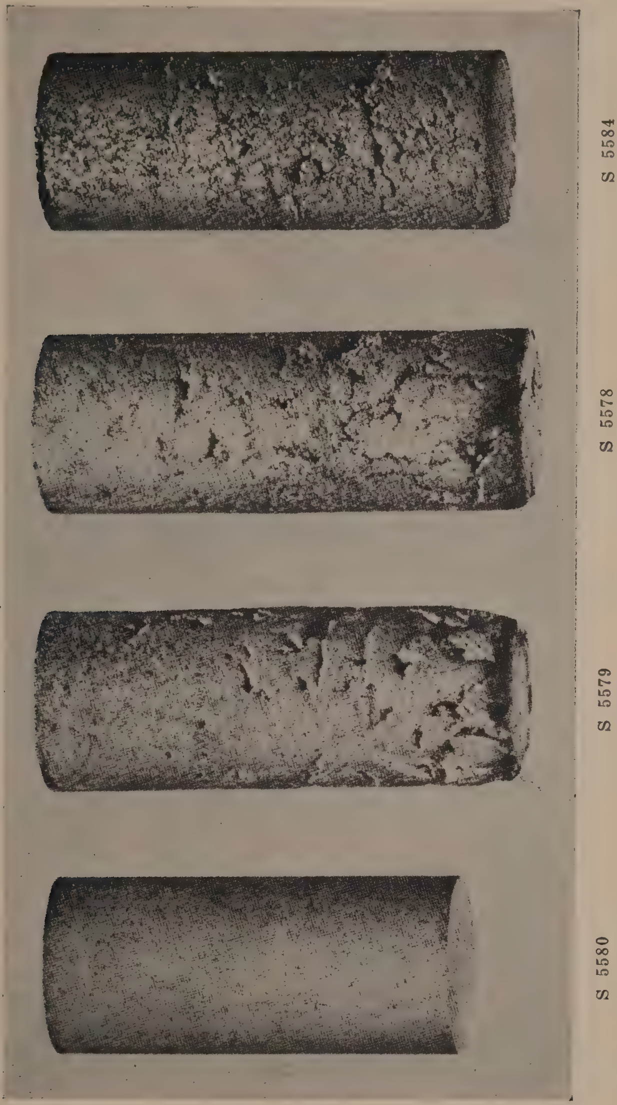

Fig. 138.—Results of correctly and incorrectly amalgamating same high A grade dental alloy. All cylinders packed under 25 kg. per cir. cm. in same mold. Wrong manipulation yields amalgam that is difficult to condense and to adapt to cavity walls. Cracks and folds weaken. Slow diffusion of mercury trapped in voids causes large and long-continued volume changes. (×4.) Bottom surfaces of same specimens, ×25, are shown in Figs. 134, 135, 136, and 137. [Gray.]

Changes in crushing strength produced by changes in amalgamation are shown by Figs. 139, 140, 141, and 142.* Although the results represented were obtained by crushing at uncontrolled room temperatures, and consequently lack the precision attainable with proper temperature control, they indicate sufficiently well the importance of using a high enough mercury-alloy ratio, triturating for a reasonable time, and packing as tightly as possible. Each of the test cylinders represented was 1.004 cm. in diameter and was made from 6 Gm. of the same dental alloy.

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*Redrawn for the reader's convenience from Figs. 7, 8, 9, and 11 of Gray, A. W.: "Metallographic Phenomena Observed in Amalgams," which should be consulted for further details.

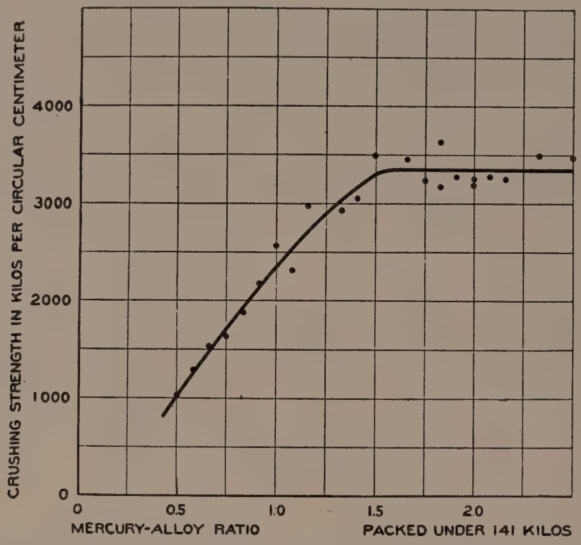

Fig. 139.—Crushing strength of amalgam increased by increasing the amount of mercury that is mixed with a high-grade dental alloy. Full strength not developed when mass of mercury is less than 1.5 times mass of alloy.

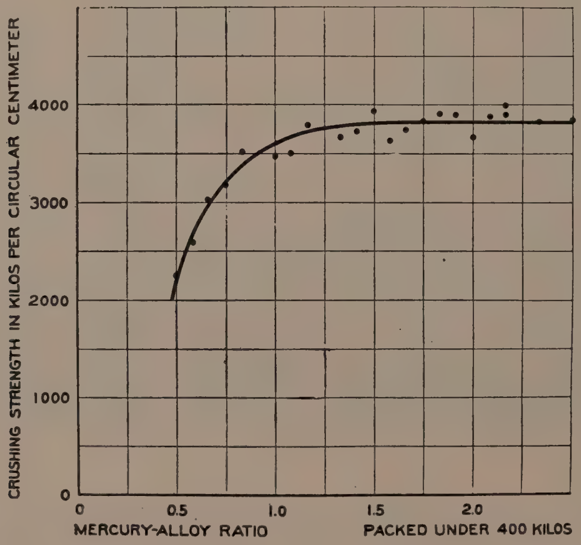

Fig. 140.—Modification of Fig. 139 produced by increasing packing pressure from 141 to 400 kg. per circular centimeter.

Because Fig. 142 indicates that the greatest strength is obtained with 6 Gm. alloy when the trituration time is about six minutes, it should by no means be inferred that this is the optimal time when a different mass of alloy is used.

With a small mix, six minutes' trituration would be excessive. A safe practical rule for the dentist is to continue trituration from one-fourth to one-half a minute longer than is necessary to produce a smooth, plastic amalgam free from granularity.

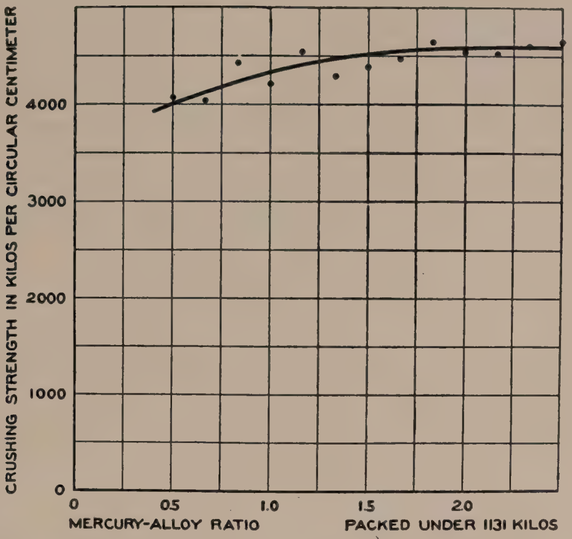

Fig. 141.—Modification of Figs. 139 and 140 by further increase of packing pressure to 1131 kg. per circular centimeter.

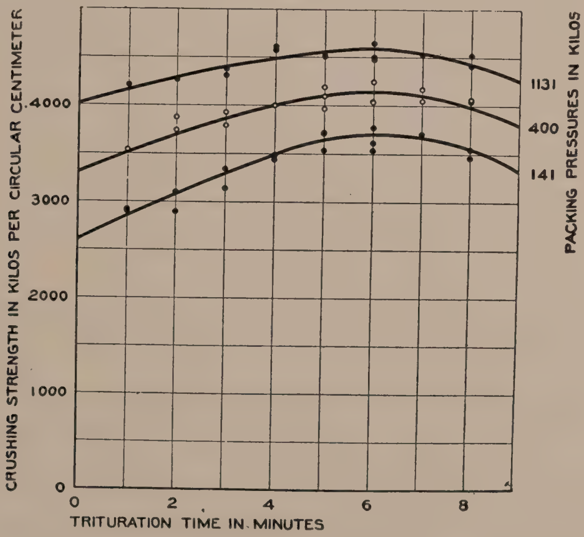

Fig. 142.—Gain in crushing strength produced by increasing trituration time. About six minutes seems optimal time for 6 Gm. alloy.

Effects of Particle Size and of Packing Pressure.—By comminution of a dental alloy into smaller particles the expansion of its amalgam can be changed into a contraction. This is illustrated by Fig. 143.* The three specimens represented were made from particles separated out of the same sample of alloy, and they were all prepared in the same way. But the particles used for specimen R 58 were large enough to be retained on a sieve having 48 meshes to the inch; those used for R 59 passed through a sieve of 200 meshes; those used for R 66 formed a very fine powder obtained by air separation. R 66 shows the first maximum so far depressed that the first and the second minima almost coincide.

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*Fig. 35 of Gray, A. W.: "Metallographic Phenomena Observed in Amalgams."

The series of curves charted in Figs. 144 to 151, inclusive, form a striking exhibition of the way in which progressive variations in both packing pressure and size of particle can make amalgams from samples taken out of the same batch of a dental alloy yield gradually changing curves of reaction expansion. They also give evidence of the remarkable accuracy attainable in expansion measurements.*

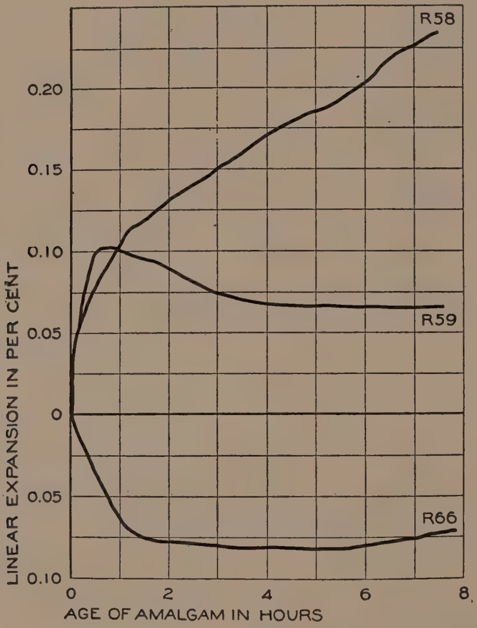

Fig. 143.—Dimensional changes of an amalgam during hardening depend upon size of alloy particles. R 58 retained by sieve of 48 meshes to inch; R 59 passed 200-mesh sieve; R 66 from very fine particles obtained by air separation.

For the investigation in which these expansion measurements formed one element, a large quantity of alloy filings from the same melt was sorted by standard sieves into five samples. The particles of the first sample passed a sieve with 100 meshes and were retained by one with 115 meshes to the inch. The particles of the fifth sample passed a 200-mesh sieve. Unsorted alloy, comprising a mixture of all sizes passing 100 meshes, furnished a sixth sample.†

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*Figs. 144 and 145 are taken from the abstract of a paper presented at the Washington meeting of the American Physical Society in April, 1921. (Gray, A. W.: Contractions and Expansions of Amalgams With Time," Physical Review 18: 108-113, 1921.) From this abstract I freely quote material that illustrates consequences of the hypothesis forming the subject of the present paper.

†This is the alloy used to show how reaction expansion is influenced by variations in trituration time. Fig. 133 and Table II.

The reaction expansion at 37.5° C. was determined for seven specimens from each of the six samples of alloy. The packing pressures under which amalgam from each sample was molded were increased in geometric progression from 25 to 1600 kg. per circular centimeter. In order to obtain the required plasticity, it was necessary to vary the mass of mercury used during trituration from 1.60 times the mass of alloy (with the mixed product and with the samples retained by sieves of 150 meshes or less) to 2 times the mass of alloy (with the samples that passed the 200-mesh sieve). Otherwise, packing pressure and size of alloy particles were the only factors that were varied.

In order to present with greater clearness the gradual changes brought about by systematic variation of packing pressure, all the curves obtained with the alloy that passed the 200-mesh sieve are grouped together in Fig. 144.

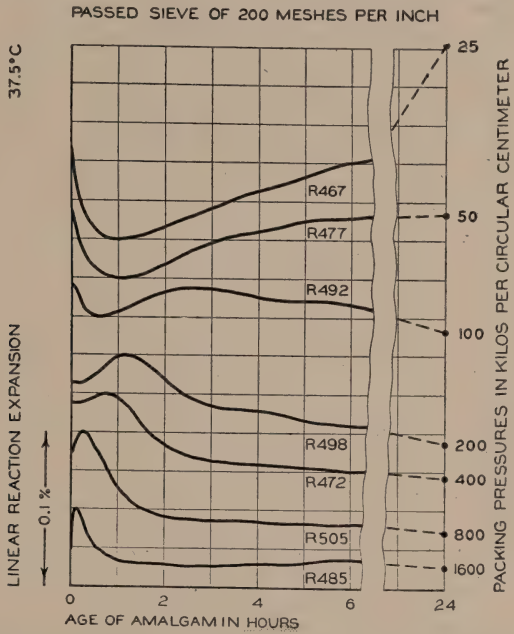

Fig. 144.—Influence of packing pressure on the reaction expansion of a dental amalgam made from an alloy containing silver, tin, copper, and zinc. Approximately 69 per cent silver. Fine particles sifted from same alloy represented by Figs. 133 to 138 and 145 to 151 inclusive.

The distance from one horizontal line to the next represents a change of 2.5 microns ($1/_{10,000}$ inch) in the diameter of a freely expanding amalgam cylinder 1 cm. in diameter, i.e., a linear expansion of 0.025 per cent. Since an observation was taken every minute during the first seven hours after a cylinder was molded, the plotted points merge into a continuous line for each specimen. The 42 curves represent more than 20,000 individual observations of diameter change. The change in twenty-four hours is indicated by a single dot at the right of the chart. Subsequent changes were followed for about a year.

The charts show that each increase in packing pressure is accompanied by an increase in the rate of reaction (solution of the alloy in the mercury followed

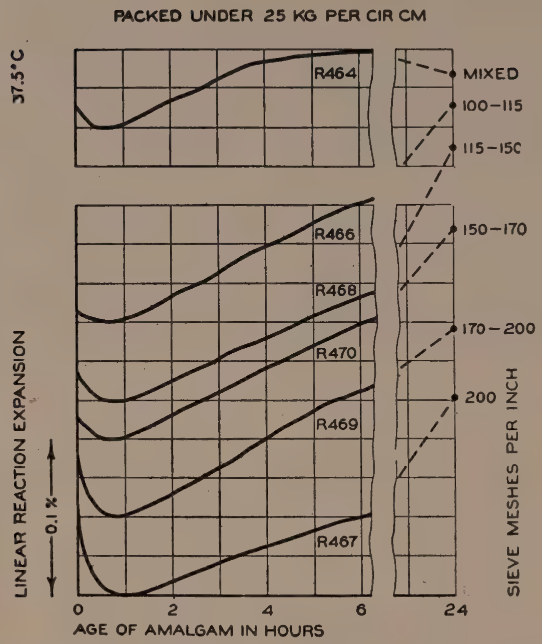

Fig. 145.—Influence of size of alloy particles on reaction expansion. Amalgam packed under 25 kg. per cir. cm.

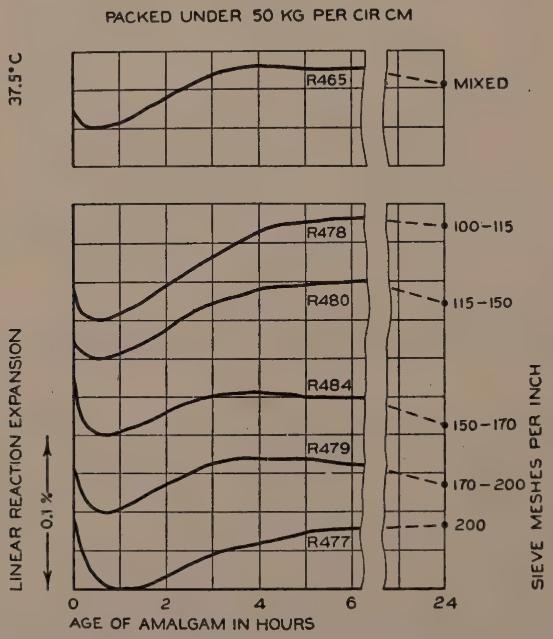

Fig. 146.—Modification of Fig. 145 by increasing packing pressure to 50 kg. per circular centimeter.

by combination and by crystallization of the amalgam), each prominent feature of the expansion making its appearance earlier than in the preceding curve. The influence of pressure change is very much greater at the lower pressures. For example, the amalgam from 200-mesh alloy (Fig. 144) packed under 25 kg. per circular centimeter requires about a month and a half to reach the first maximum. Doubling this pressure results in the maximum being reached during the first twenty-four hours. Another doubling shortens the time to about two and one-half hours. Additional increments of pressure progressively hasten the appearance of this maximum until under 1,600 kg. it is reached in less than ten minutes. At the same time, the increase of pressure progressively obliterates the initial rapid descent preceding the first minimum, and it finally obliterates some of the following rise toward the first maximum. It also hastens the appearance of the second minimum, which is reached in about three weeks with 50 kg. and in about three hours with 1,600 kg. With this alloy, the rise from the second minimum to the final maximum is very slight, being less than 0.1 per cent in the course of a year. Any initial contraction caused by either fine cut of alloy or high pressure, or both combined, was always made up by the time the amalgam became apparently stable, the final diameter of every test cylinder being a few hundredths of a per cent larger than when measurements were begun immediately after the cylinder was molded.

Fig. 145 shows how variations in size of alloy particles affect the reaction expansion of amalgams packed under 25 kg. per circular centimeter. The following charts show similar results for amalgams packed under other pressures.

The figures to the right of each curve give the number of meshes per inch of the sieve that passed and the sieve that retained the alloy used for the amalgam represented by the curve. The curve at the top of the chart was obtained from the unsorted dental alloy, that is to say, from alloy in which patricles of all the various sizes represented by the other curves were mixed in proportions that yielded a commercial product of the highest grade.

The control of the reaction expansion produced by this blending of various-sized particles is evident on comparing the curve of specimen R 464 with the other curves on the same chart, especially when the comparison is extended to include observations made at intervals during a period of several months. For example, specimen R 467 expanded 0.18 per cent beyond its first minimum, or 0.11 per cent beyond its diameter when observations began a few minutes after molding, before it attained its first maximum a month and a half later. The other amalgams from the sorted particles of alloy behaved very much like this, although gradual changes in the expansion curve are noticeable as the alloy becomes progressively coarser.

In contrast with the specimens from sorted particles, R 464 attains its first maximum in a few hours, with an expansion of less than 0.05 per cent beyond its first minimum, or about 0.03 per cent beyond its initial diameter. Contraction of about 0.02 per cent to the second minimum, and final expansion almost too slow for reliable measurement, leave the amalgam at the end of a year

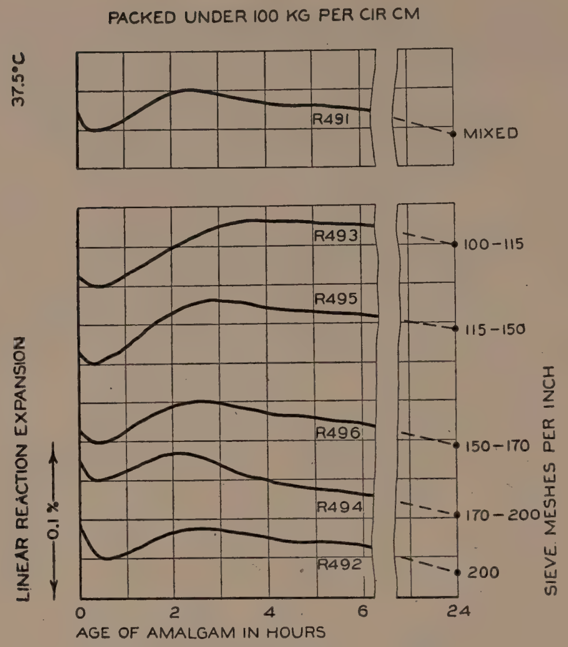

Fig. 147.—Influence of size of particles when amalgam is packed under 100 kg. per circular centimeter.

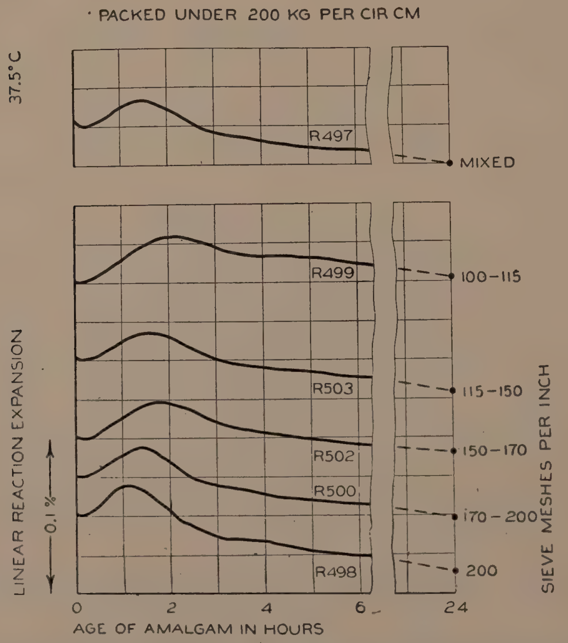

Fig. 148.—Influence of size of particles when amalgam is packed under 200 kg. per circular centimeter.

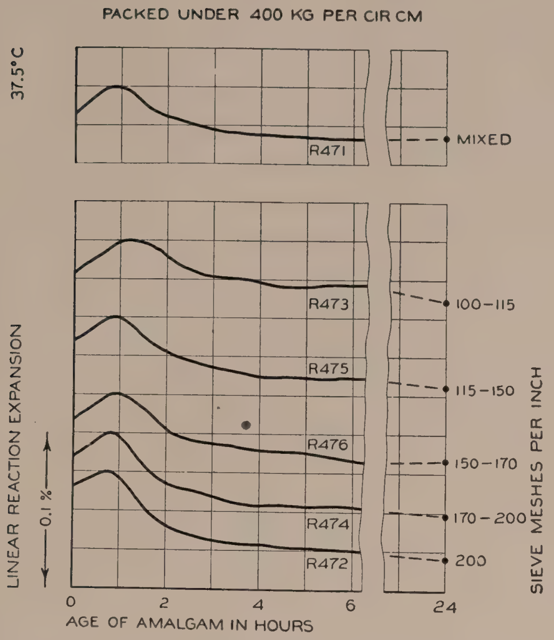

Fig. 149.—Influence of size of particles when amalgam is packed under 400 kg. per circular centimeter.

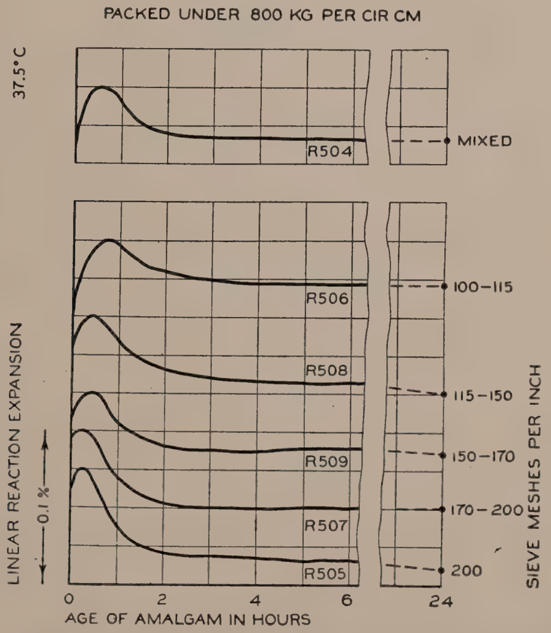

Fig. 150.—Influence of size of particles when amalgam is packed under 800 kg. per circular centimeter.

about 0.05 per cent larger than when first measured. The same amalgam when packed under 50 kg. gives an expansion curve that is practically the same in all respects as the curve of R 464.

The limitation of dimensional changes exhibited by the curve of R 464 is not an accident of experimental procedure. It is a direct consequence of blending alloy particles that differ in size; this is shown by many almost identical curves obtained during routine tests of different lots of similarly made alloy. When the particles of a dental alloy are graded in size so as to reduce to a minimum the volume of the voids existing among them before amalgamation, it is reasonable to expect that even after these voids have been modified by trituration, less liquid mercury would be retained within them after the excess is squeezed out during packing. The mercury contents actually found in the test cylinders used for these expansion measurements support this expectation.

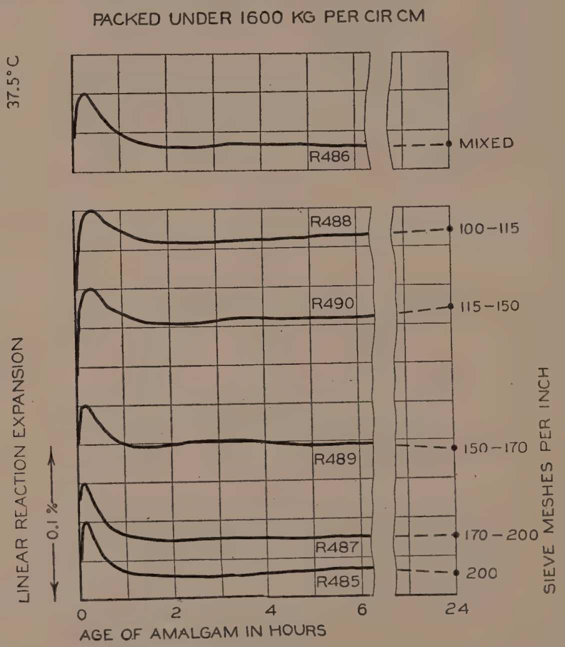

Fig. 151.—Influence of size of particles when amalgam is packed under 1600 kg. per circular centimeter.

Typical structures of amalgams from four well-known American high-silver dental alloys are exhibited in Figs. 138, 153, 154, 155, and 156. Each test cylinder was prepared from 2 Gm. alloy amalgamated strictly according to the directions furnished by its manufacturer, and was packed in the same steel mold under the identical conditions stated in describing Figs. 134, 135, 136, 137, and 138. Differences in quality are obvious.

The blended alloy previously described in detail is represented by specimen S 5580, Figs. 138 and 156. This alloy yields a fine-grained, uniform, plastic amalgam that facilitates good adaptation. When properly manipulated, volume changes during hardening are negligible. The strength is high. There is no flow under masticatory stresses. Being properly annealed, neither the alloy nor its amalgam deteriorates with lapse of time, provided it is kept reasonably clean and is not subjected to gross abuse, such as storing in an unusually warm place or exposure to an atmosphere contaminated by chemicals. By the procedure described, its setting rate can be easily controlled by the dentist so as to afford ample time for making large restorations.

Specimen S 5569, Figs. 153 and 156, was made from a very finely cut alloy. Its close structure suggests good quality, but dilatometric measurements show excessive contraction during hardening. Moreover, although the alloy contains about 68 per cent of silver, a given weight of it yields a considerably smaller volume of amalgam than is yielded by the same weight of the previously described alloy. In this respect, as well as in its excessive contraction, it resembles ordinary low-grade alloys, which also yield fine-grained, smooth amalgams.

Specimen S 5560, Figs. 154 and 156, shows a rather coarse-grained amalgam, traversed by numerous cracks and folds that hinder good condensation and close adaptation to the walls of the cavity, as may be seen by the fact that the amalgam has failed to take an impression of the base-line angle of the cavity, although the cylinder was condensed under the same packing pressure used in condensing the other cylinders of the group. Large, long-continued dimensional changes characterize amalgams from this alloy. In one case the amalgam reached its first minimum in half an hour, after a linear contraction of about 0.04 per cent. It then expanded 0.01 per cent to its first maximum, which was reached within three hours after molding. The second minimum was reached in about a day, after a contraction of 0.02 per cent below the first minimum, or 0.06 per cent below the diameter when observations began. After this, the amalgam steadily expanded toward its second maximum, which was not reached in eight months, when observations had to be discontinued because the cylinder had grown so large that readjustment of the dilatometer would have been necessary for further measurement. The diameter of the specimen had increased 1.28 per cent and was still expanding. Since the growth characteristic of amalgams from this alloy does not become evident until after several days, it is easy to understand how it has apparently been overlooked by previous investigators.

Specimen S 5571, Figs. 155 and 156, was made from a rather coarsely cut alloy, that makes a ''dry'' mix, so difficult to condense that it requires heavy mallet-packing to obtain even fair adaptation to the cavity walls. Note how this amalgam also failed to give an impression of the cavity. The amalgam is permeated with countless cracks and large cavities. The alloy is improperly annealed. It changes with age.

Molding under a greater packing pressure would have improved the structures of all these amalgams, and it would have rendered the differences among them less noticeable; but a greater mean effective packing pressure is not always feasible in making an amalgam tooth restoration. The smoothing-out of surface

Bottom surfaces of same dental amalgam cylinders shown in Fig. 156, ×25. Oblique illumination.

Fig. 152.

Fig. 153.

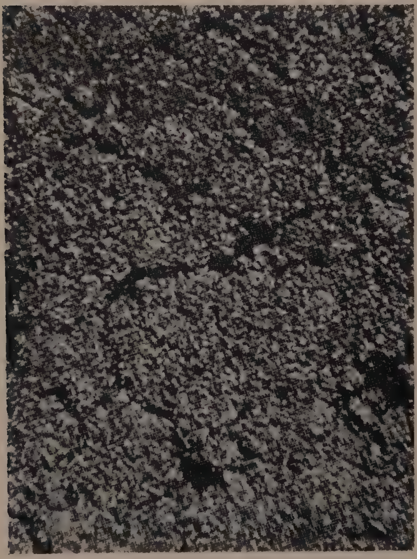

Fig. 154.

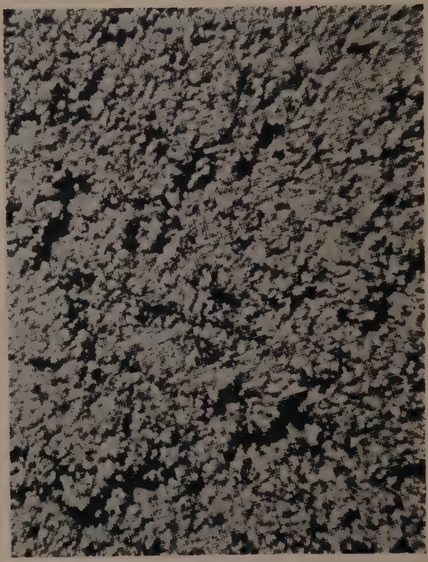

Fig. 155.

Fig. 152.—Good alloy correctly amalgamated yields fine-grained, uniform plastic amalgam that facilitates good adaptation to cavity walls. Negligible volume changes. High strength. No flow under masticatory stresses. S 5580, Figs. 138 and 156.

Fig. 153.—Close structure suggests good quality, but this amalgam contracts excessively during hardening. Alloy yields small volume of amalgam. S 5569, Fig. 156.

Fig. 154.—Rather coarse-grained amalgam, traversed by numerous cracks and folds. Large long-continued dimensional changes characterize amalgams from this alloy. S 5560, Fig. 156.

Fig. 155.—Amalgam from rather coarsely cut alloy, that makes a "dry" mix, so difficult to condense that it requires heavy mallet-packing to obtain even fair adaptation to cavity walls. S 5571, Fig. 156. [Gray.]

defects that will naturally be done when packing test specimens by hand-pressure or by mallet blows on dental instruments will, of course, improve the external appearances. One must not assume that a good superficial appearance indicates absence of internal defects.

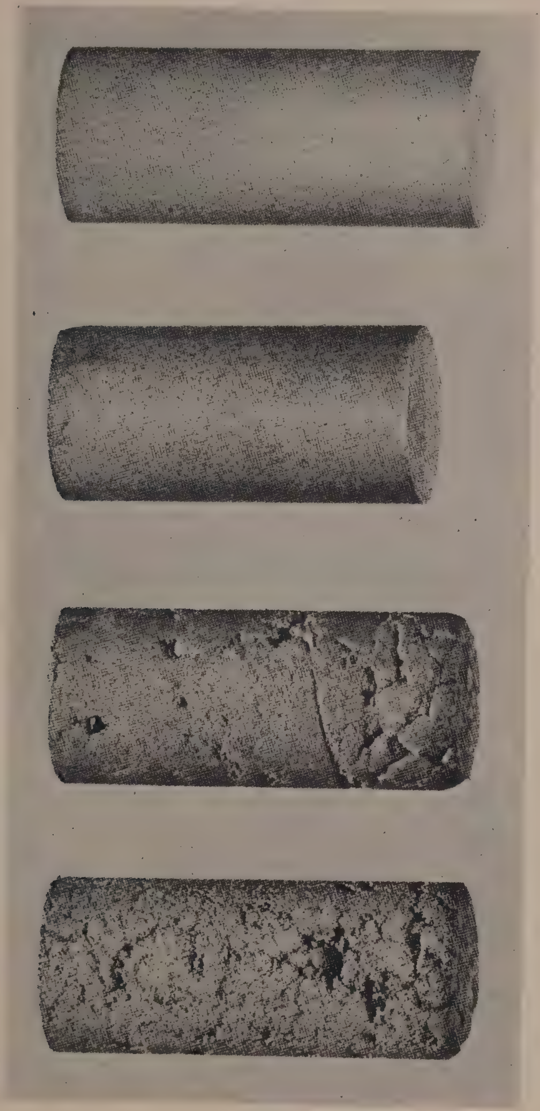

Fig. 156.—Amalgams from four well-known American high-silver dental alloys. Each was amalgamated strictly according to directions furnished by its manufacturer, and packed under same pressure in same mold. Note differences in volume from same weight of alloy. Cracks and folds hinder good condensation and close adaptation to cavity walls; shown by failures to take good impression of base line angle of cavity. (×4.) Bottom views of same specimens, ×25, are shown in Figs. 152, 153, 154, and 155. [Gray.]

That defects of the kind shown by Figs. 135 to 138 and 154 to 156 inclusive are quite as serious as excessive contraction will be apparent to anyone who will take the trouble to examine the concealed portions of a considerable number of fillings in extracted teeth. The photographs show that it is easier for the dentist to secure good adaptation with some alloys than with others.

Figs. 145 to 151 show that, as the packing pressure is increased, the effect of variation in size of alloy particles becomes progressively less.

The contraction found during the early stages of hardening when amalgam from a properly adjusted dental alloy is packed under a very high pressure does not in any way prevent the making of a tight tooth filling, because packing hard enough to cause contraction in such an amalgam will stretch the resilient dentine more than enough to make it follow the slight shrinkage of the filling. In fact, moderate contraction after very tight packing is an advantage in that it relieves to some extent the straining of the tooth. The tighter the packing, the better the filling, because heavy packing pressure not only adds to the strength of the amalgam, but also shortens considerably the time required for it to complete all its dimensional changes and become stable. Moreover, it secures much better adaptation of the filling to the cavity walls and, consequently, reduces liability to leakage.

The packing pressures used in this investigation extend from well within the dental range to considerably beyond it. The mean effective packing pressures employed by different individuals, in condensing amalgam fillings with dental instruments, vary widely. I found the average for four individuals to be 68 kg. per circular centimeter. The average deviation from this was 64 per cent; the difference between the highest (234 kg.) and the lowest (17 kg.) was 321 per cent.* Such deviations taken in conjunction with the pressure effects shown in Fig. 144 indicate that, regardless of the accuracy of the particular device employed for measuring the dimensional changes, too much reliance must not be placed on comparisons of dental alloys that are based on expansion tests of amalgams packed by hand pressure or by mallet blows.

The mercury contents of finished test cylinders of the amalgams represented by Figs. 144 to 149 were found to increase regularly as the alloy particles became progressively smaller. Although increase of packing pressure from 25 to 1,600 kg. per circular centimeter reduced the mercury content in an amalgam of the coarsest sample from about 55 per cent to about 30 per cent, change of particle size to that passing the 200-mesh sieve increased the mercury content by only about 2.5 per cent. This increase appeared to be independent of the packing pressure. The blended sample regularly yielded almost the lowest mercury contents at all packing pressures, apparently because grading of the particles according to size reduced the voids available for retaining the liquid mercury-tin solution after the amalgam was condensed by pressure.

A simple calculation shows that if a dental alloy contains 68.8 per cent silver, like the alloy used in the investigation just discussed, there need be no fear of retaining a deleterious quantity of mercury in any tooth filling made with it that is packed into the cavity with reasonable tightness. Three × 108 Gm. silver combines with 4 × 200 Gm. mercury to form (324 + 800) Gm. Ag_3Hg_4. Therefore, the mass of mercury that can be used by a dental alloy to form Ag_3Hg_4, without leaving, after reaction is completed, any excess to be retained in a soft solid solution of mercury in tin, is 800/324 = 2.47 times the mass of silver contained in the alloy. Consequently, the mercury that can combine with the silver in an alloy containing 68.8 per cent of the latter metal is 2.47 × 0.688 = 1.70 times the mass of the alloy. The retention of 1.70 Gm. mercury per gram of alloy would yield 2.70 Gm. amalgam. The mercury content of the amalgam would, therefore, be 1.70/2.70 = 63 per cent.

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*See reply to discussion of paper by A. W. Gray, entitled, "Transition Phenomena in Amalgams," Tr. Am. Inst. Mining and Metallurgical Engineers, 64: 507, 1920, and reprinted in J. Nat. D. A. 8: 491, 1921.

The use of a higher mercury-alloy ratio to facilitate amalgamation would not under any reasonable dental procedure result in retaining an excess of mercury. Even when a sample of alloy fine enough to pass the 200-mesh sieve was triturated four minutes with 2.00 times its mass of mercury, and packed under only 25 kg. per circular centimeter, the mercury content of the resulting test cylinder reached only 60.4 per cent. The highest mercury content found in a cylinder from the blended commercial product was only 55.2 per cent, leaving as a margin of safety about 8 per cent of the mass of amalgam, or about 8/55 = 14.5 per cent of the mass of mercury retained under this low packing pressure. The presence in the alloy of 5 per cent copper, which can also unite with mercury to form a strong amalgam, must increase the margin of safety considerably.

Effects of Temperature During Hardening.—Figs. 29 and 30 of "Metallographic Phenomena Observed in Amalgams" show how both combination and crystallization become retarded upon reducing the temperature during hardening from 37.5° to 25° C. By cooling to 5° or 10° C., I have produced such retardation that it takes many hours to establish the existence of a slow contraction following the flat maximum in the curve of reaction expansion.

If a soft, freshly mixed dental amalgam is placed upon carbon dioxide snow, it will harden rapidly by freezing; but reaction will be so retarded that the amalgam will resume its plasticity as soon as it is warmed to room temperature. Reaction followed by hardening will then proceed as usual. In this way normal hardening of the amalgam can be postponed for a long time.

Commercial application of cooling by means of CO_2 snow has been attempted for controlling the setting of dental amalgams, in order to give the dentist ample time for completing a large restoration with a high-grade, and consequently rapidly setting, alloy. But the attempt does not seem to have been successful. The method is unnecessarily troublesome.

A simpler method of controlling setting time is to triturate the alloy with plenty of mercury and to leave the excess mercury in the mix, to be expressed from each small portion of amalgam just before it is placed in the tooth cavity. Further excess brought to the surface of the filling during packing is removed as it appears. This method of maintaining an amalgam in a workable condition affords ample control for all practical purposes.

Precautions Necessary in Measuring.—Upon several occasions I have pointed out that measurements of reaction expansions may lead to erroneous conclusions unless particular attention is paid to the control of influencing conditions.*

**Loc. cit.*

Accurate measuring instruments of sufficient sensitivity are, of course, necessary for obtaining reliable results in any investigation. But instrumental accuracy is wasted, and frequently misleading, if measurable parasitic effects of unknown magnitude are not excluded. Liableness to misleading indications is particularly great when very sensitive detectors are used.

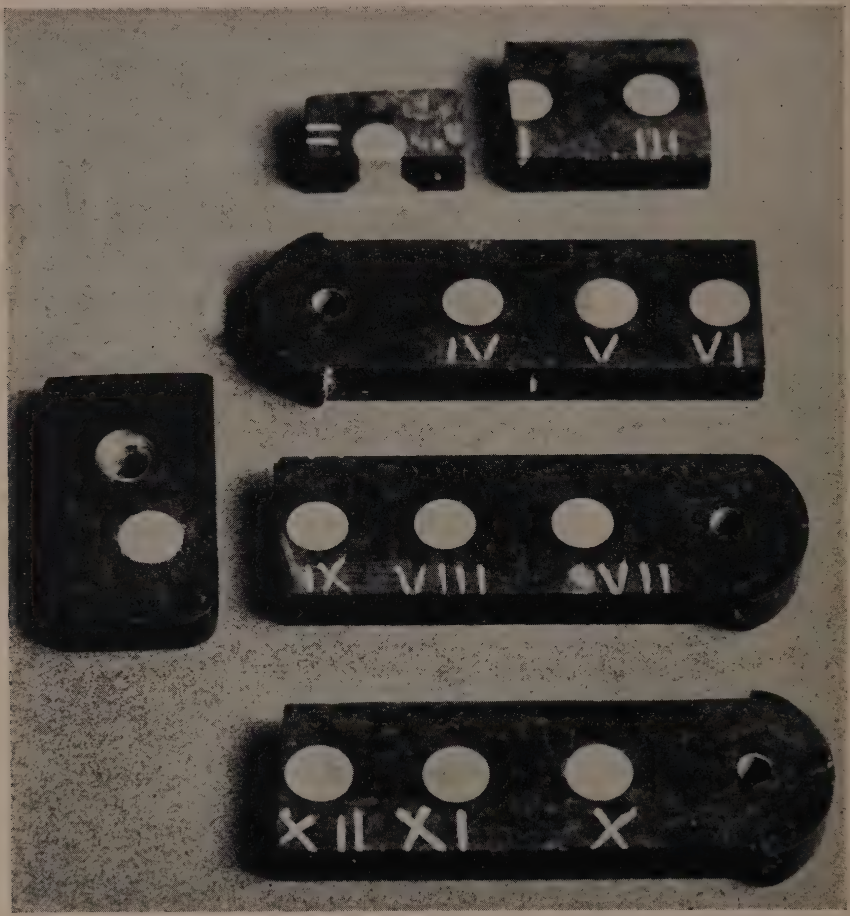

Fig. 157.—Photograph showing results of correct and abused technic. Some show a secondary expansion at the end of sixty days of as much as 167 microns. Another shows a shrinking of as much as 125 microns at the end of sixty days.

Control of temperature is nearly always important; but it is often neglected because it costs some extra trouble. Temperature variations affect the dimensions of both the measuring apparatus and the specimen under investigation. Usually it is easier to eliminate the variations than it is to apply corrections to the observations, particularly since it is difficult, if not impossible to estimate some corrections even approximately.

Since the linear thermal expansivity of a dental amalgam is about 0.000025 per degree Centigrade, a temperature variation of 1 degree will change the length of a 1-cm. specimen 0.25 micron. Results obtained at uncontrolled room temperatures with an interferometer sensitive to 0.005 micron are, therefore, not nearly so reliable as results obtained with a less but sufficiently sensitive instrument and accurate control of temperature. The dilatometer used for obtaining the curves shown in this paper is accurate to 0.05 micron; the temperature of the specimen during measurements seldom varies 0.01° from 37.5° C., or from whatever other temperature is selected.

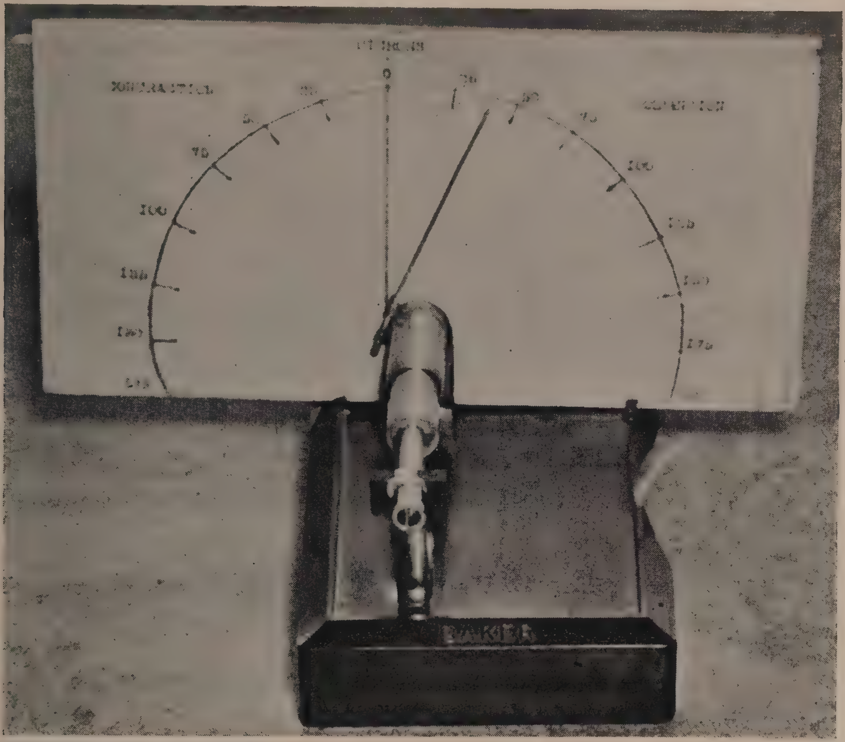

Fig. 158.—A micrometer designed by the author which was used in the testing of amalgam, silicate, and cement as reported. The pointer shows 35 microns expansion.

Even when effects of thermal expansion can be disregarded, the investigator of dental amalgams should never forget that a moderate change of temperature may produce marked effects upon such processes as diffusion, solution, chemical combination, and crystallization. Since the dimensional changes observable during hardening depend so much upon the rates at which all these processes occur, it is hardly safe to assume that temperature control may be neglected because a few short-time trials at differing temperatures fail to show pronounced effects. A small change in composition or in manipulation may result in an amalgam that is far more sensitive. Since dental amalgams are used at the nearly constant temperature of the human mouth, most tests for the purpose of comparing different dental alloys should be made at a constant standard temperature not far from that of the mouth. We use 37.5° C.

Control of amalgamation procedure and of packing procedure is often even more important than control of temperature. This should be apparent from the experimental data presented.

Finally, since diffusion, solution, chemical combination, and crystallization proceed very slowly in solid substances, dental amalgams under investigation should be observed at regular intervals until it becomes reasonably certain that no further changes of importance will occur. Failure to realize the possibility of significant cumulative effects from long-continued retarded reactions apparently accounts for conclusions that some inexperienced investigators have drawn from their short-time tests of dental amalgam alloys.

Correct Technic

M. Malleted. H. Hand packed.

No.
1. M. A. 9 Microns expander.
2. M. A. 4 Microns expander.
3. M. A. 23 Microns expander.

Expansion Tests. Abused Amalgam

Sixty days after filling. M = Microns.

4. M. Wet cavity. Palmed. First portion of amalgam soft with mercury. 60 M+.
5. M. Wet cavity. Palmed. All portions of amalgam squeezed dry with fingers. 167 M+.
6. M. Wet cavity. Palmed. Insufficient trituration. 50 M+.
7. M. Dry cavity. Machine mixed. First portion soft with mercury. 50 M+.
8. H. Dry cavity. Mortar mixed. Palmed. Too soft. 30 M +.
9. H. Dry cavity. Mortar mixed. Palmed. Insufficient mercury. 75 M—in 24 hours. 125 M—in 30 days.
10. M. Wet cavity. 1.50 per cent zinc. Machine mixed. Palmed. Second portion used after dropping in saliva. 50 M+.
11. M. Dry cavity. 1.00 per cent zinc. Machine mixed. Palmed. Last portion softened with added mercury. 15 M +.
12. M. Dry cavity 0.03 zinc. Palmed. All portions squeezed dry. 5 M +.

(See Fig. 157.)

CHAPTER XXXIII

THE USE OF CEMENTS IN FILLING TEETH

Varieties.—There are four main varieties of cement available for use in the operation of filling teeth: oxyphosphate of zinc, oxychloride of zinc, sulfate of zinc, and oxyphosphate of copper.

Cavity preparation for cement when the entire filling is to be of cement is not unlike that for any other filling, except that the cavosurface angle is left as produced by the cleavage of the enamel, omitting the marginal bevel. The cavity should be given the usual retention form, and the matrix must be employed in cavities to supply the missing wall, that the cement may be introduced with pressure to condense and create close adaptation to walls.

The rules given for dryness in the manipulation of gold and amalgam are required for cement.

The oxyphosphate of zinc has many uses in the cavities of teeth as a partial filling and in some instances for the complete filling. As it is a poor conductor, it is an excellent agent as an intermediate between metal fillings and nearly approached pulps.

Its adhesive quality gives it great value as a means of adding retention to all kinds of metal fillings. This quality, together with its color harmonious with tooth substance, makes it invaluable for lining weakened enamel walls which have lost much of their supporting dentine.

Its chief fault is its tendency to dissolve in the fluids of the mouth, which renders it comparatively temporary. There is a considerable variation in its behavior in different mouths, however, as in some instances it wears for years.

Oxychloride of zinc is indicated in pulpless teeth to fill the pulp chamber after the canals have been previously filled with gutta-percha, and for the lining of cavities for the preservation of color where adhesiveness is not of importance. It is not indicated in teeth with nearly approached vital pulps or as a root filling on account of its irritating properties.

Oxide of zinc when pure is the least irritating of all cements and is one of the best materials for pulp protection. A pulp capping of the oxide of zinc is of almost universal application when mixed with oil of cloves.

Oxyphosphate of copper is especially indicated in remote cavities on the necks of teeth which have been occasioned by gum recession. Cavities which are so ill-defined that the use of amalgam or gutta-percha is difficult may be successfully filled with this preparation of copper.

It can be made to adhere very tenaciously to the walls of a cavity, obviating much cutting. Oxyphosphate of copper is also indicated in the small cavities in the deciduous teeth. It is claimed to exert a therapeutic influence upon the tooth substance, preventing further decay.

Manipulation of Oxyphosphate of Zinc Cement.—The method of mixing this cement is not in the least difficult, yet certain details are essential. The slab should be clean; smooth glass is preferred. The spatula should be flat, with the side slightly convex. Agate, stellite, or stainless steel are the best materials, as they are not acted upon by the liquid. The liquid and powder should be placed upon the slab separately. The drop of liquid should be carried there by the use of a small glass tube. The spatula should never be immersed in the bottle to obtain more fluid, as this will destroy the efficiency of the liquid. Crystallized portions should be carefully wiped off the mouth of the bottle as soon as detected.

Plan of Spatulating.—The powder should be added to the liquid a little at a time and each portion should be thoroughly rubbed by a swinging circular movement of the spatula upon the slab. This rubbing should be rapid and vigorous and the powder should be added till the consistency desired is obtained. For lining cavities where thin layers are desired which are very adhesive, the cement will prove correctly mixed when it shows slight stringiness, and when the first stickiness appears as shown by the slight resistance offered the spatula in its movement over the slab. Where the entire filling is to be of cement, more powder should be added and the spatulation vigorously continued till the cement materially resists spatulation and the mass is the consistency of freshly made putty. When cement is of the consistency desired, no time should be lost in placing it in position, and it should be allowed to harden undisturbed. If the cement is to form the entire filling, and as much permanency as possible is desired, it should be malleted to place with some force and rapidly shaped up. As soon as crystallization begins, it should not be disturbed by manipulation till it has fully hardened, when it should be smoothed and polished with fine strips and disks.

Research With Our Cements

A study of the behavior of our cements under a glass inlay, and their comparative adhesive qualities as shown by the draw-bar strain for their dislodgment, is of interest, to say the least.

It has been twelve years since we gave similar tests and we find there have been many changes in the formulas as well as in the methods of manufacture and compounding. In some instances these changes have resulted in improvements, and in other cases the cement has been materially damaged.

We shall first consider the technic involved in determining the changes in the cements as seen through glass inlays.

Taking a first upper molar tooth made of plaster and exaggerated in size, we carved a mesial cavity.

To represent the axial wall, we imbedded an inch-square ground glass wrapped in No. 40 tin foil.

To represent the inlay we fitted an inch-square section of clear glass. We then spread crown and bridge cement over the rough glass axial wall and set the glass inlay under sufficient pressure for five minutes to produce a layer of cement 0.001 thick by the micrometer. (See Fig. 160.)

Temperature Control.—The tooth was filled at body temperature. The cement mixed on a slab at 60° F.

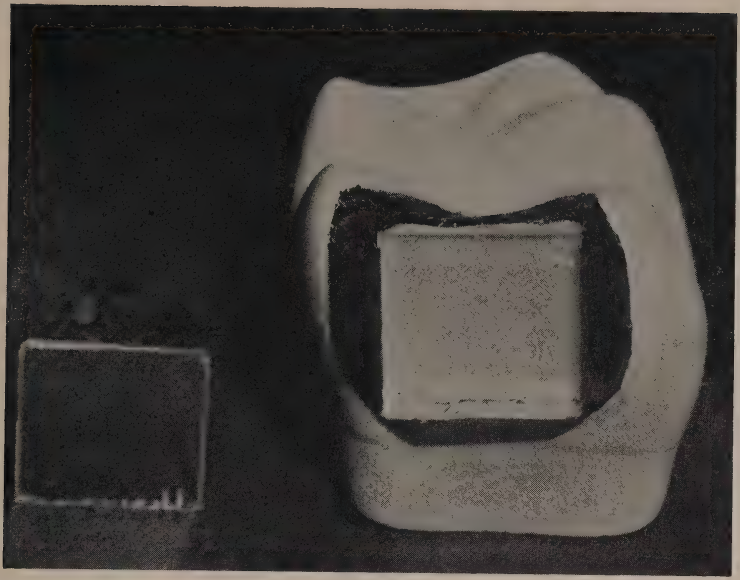

Fig. 159.—Tooth with ground glass cavity. Beside that a clear glass inlay which, when cemented, gives opportunity to study the behavior of the various cements on the market. It is also of value to note the movements of excess mercury in packing amalgam.

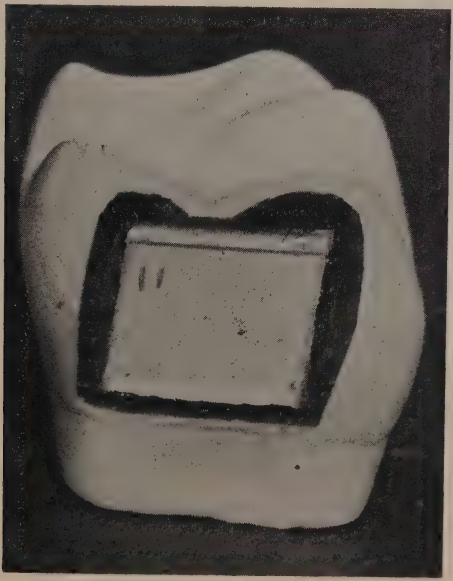

Fig. 160.—Showing the clear glass inlay cemented to place. This is No. 3 shown in Fig. 161.

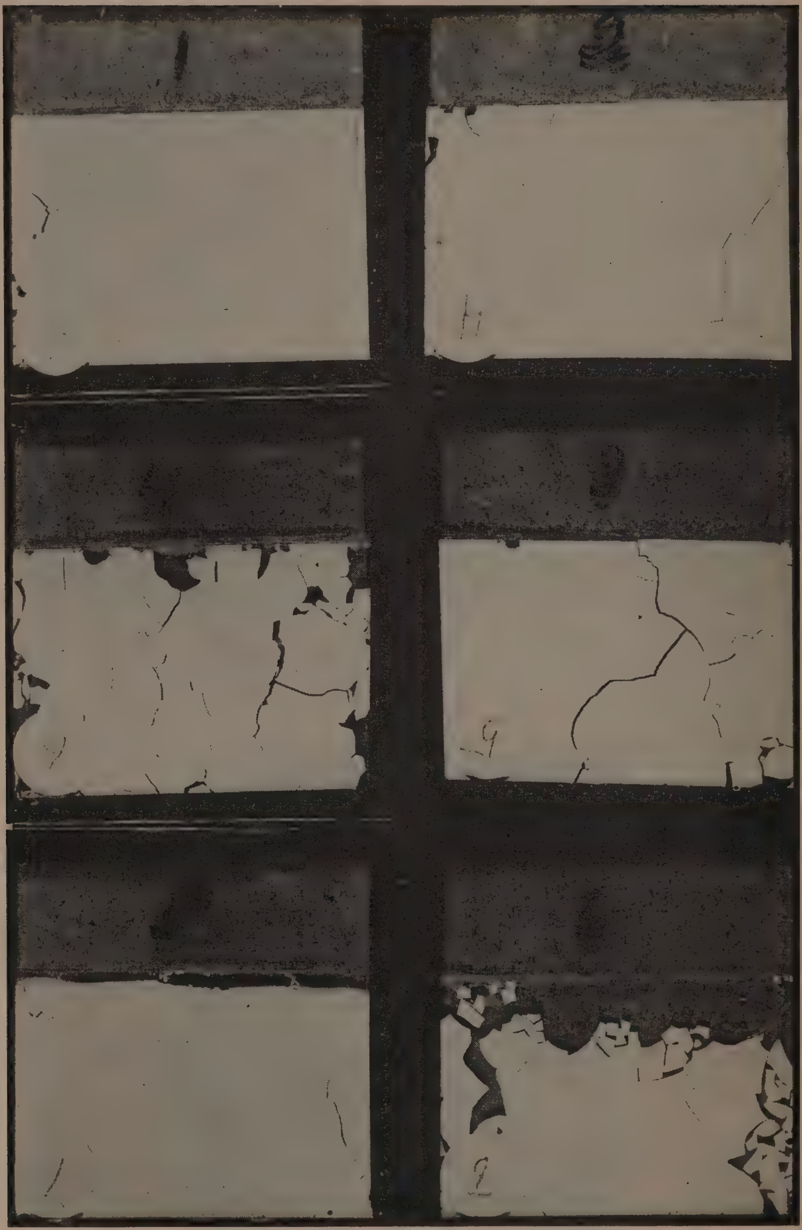

Fig. 161.—Cement was mixed in these six tests to a consistency for setting inlays, according to the directions accompanying each package. Mouth temperature was maintained. The cement was placed between two glass cover glasses, one of which was ground to represent a cavity wall. The other was a clear glass inlay. They were each set under sufficient pressure to produce a film of cement of 0.001 inch. In about thirty days each had checked as this picture shows. These six makes cover at least nine-tenths of the covers used in the United States.

Question: Then why do our inlays not fall out? Plenty of them do, but the answer is: grease from our food which soon fills the checks, shutting out the water.

Advice: Grease every inlay with petroleum jelly modified with cocoa butter as soon as placed. Never use varnish.

During the entire course of these experiments, the usual correct technic was followed, body temperature was secured, and the usual timing practice was observed.

At the end of five minutes, the pressure on the inlay was removed (the excess cement dressed away, and the usual moisture of 90° F. was admitted on the exposed occlusal cement margin. Immediately the moisture penetrated beside the inlay to the very base of the gingival wall. This happens with most cements. Try the one you are using.

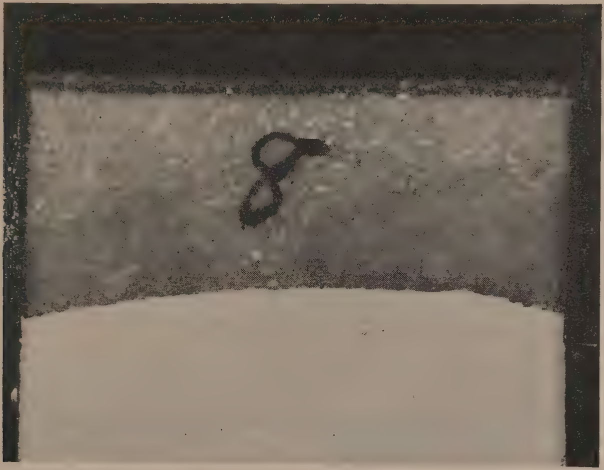

Fig. 162.—This cement was given the same tests as those shown in Fig. 161 and no cracks have appeared after one year.

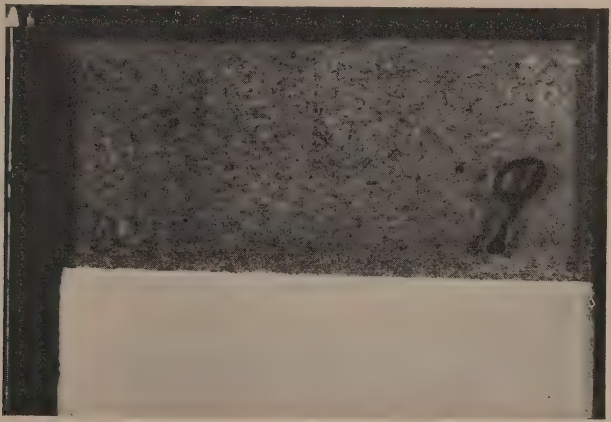

Fig. 163.—Cement No. 9 is of our own compounding, and contains a small amount of fluorine.

To decrease the bulk of technic equipment which would result from repeated tests with the twelve makes of cement on the market, we substituted small tablet boxes with complete protection from the plaster by incasing in tin foil and sealing all margins but one with white enamel paint.

In each case we applied the pressure five minutes, dressed the excess cement away, and applied water at 90° F. to simulate the condition obtained if the patient closed the mouth not later than ten minutes from the time of setting the inlay.

The next day and for several days, three times a day, we simulated temperature changes at mealtime, as when drinking hot coffee and eating ice cream. Body temperature was maintained in the intervals.

Through the clear glass inlay we watched the cement crack into sections and shrink from the inlay. This was true of most popular makes but not all.

We then varied the technic by using a glass inlay ground on the cementing side. This was to simulate the setting of an inlay, the cavity side of which had been engraved with a sharp-pointed instrument as with the point of a gingival marginal trimmer.

With most cements, the cement continued to crack and the moisture to penetrate. However, when the inlay was removed, some of the sections adhered to the cavity wall and some to the inlay, whereas, with the smooth surface inlay, all sections adhered to the cavity wall. This explained why some of our inlays are mechanically retained long after the cracks in the cement have contained fluids of the mouth.

Adhesion of Our Cements to Resist the Draw-Bar Strain.—Our inlays are never removed from the cavity in the direction of the bases. They are always pulled from the cavity; hence, the adhesion of the cement to both cavity wall and inlay is of major importance.

This is best determined by their resistance to the pulling force applied at the age when they first go into oral service or at about thirty minutes after placing the inlay.

In this chain of tests we used twelve brands of cement. Temperature was controlled as to mixing, setting, and usage in practice. Two gold inlays were used, one with a smooth surface and one with an engraved cavity surface, each a round disk 10 mm. in diameter, with a loop soldered in the center.

The size of the inlay was such as to give a cementing surface about equal to that of a two-surface cavity in a molar tooth. This makes a surface of about 78 sq.mm. The scale used was a United States postal scale adapted to our tests. The disks, one smooth and the other with an engraved cavity on the cavity side, were cemented to a ground plate glass surface.

General practice was simulated. All twelve cements were repeatedly tested. A slab of a temperature of 60° F. was used. Cement was applied to both cavity wall and inlay. The inlay was placed under pressure with a 0.001 film of cement. After five minutes the marginal cement was trimmed away and moisture was admitted.

At the end of thirty minutes each filling was submitted to the draw-bar strain. As no load was sustained by some, and great loads were required to dislodge others, tests were repeated to eliminate accidents and errors. Some fell off before we could get them to the machine while others sustained surprising stress. Thus far the tests were conducted to simulate usual instructions and operative practice.

To vary the research and personally learn more about this trying condition of loosening inlays which occurs in the work of all operators, we carried the whole lot through as above, with modified technic. As soon as the excess cement was trimmed from the margins and before moisture had been admitted, we coated the entire cavity outline with heavy coats of grease, as from food. As we had suspected, the force to dislodge was materially increased in most makes of cement, particularly with those cements of which the powder was composed of zinc oxide and a small percentage of silicate.

Conclusions

After completing our research with today's cementing media for the fixation of our inlays, crowns, and bridges, we were forced to come to the following conclusions:

First, there is a tremendous difference in the efficiency of the cements offered to dentists by the manufacturers.

Second, many cements shrink beyond the point of usefulness within a few minutes after use. These are found in the clear zinc powders. Also, the finer the grind, the greater the shrinkage.

Third, a few cements show no dimensional change of importance at any stage after the five minutes of setting under pressure. In this group are those made up largely of silicate with a small percentage of zinc oxide added. One brand is too heavily loaded with zinc oxide and promptly cracks and shrinks true to the faults of the clear zinc cement.

Fourth, in the draw-bar strain the gold inlay with the engraved cavity surface gave the greatest resistance to removal with most brands of cement.

Fifth, the greasing of all margins with a generous coating before immersing in water at 90° F., or, before dismissing a patient, further increased the load necessary for dislodgment.

CHAPTER XXXIV

COMBINATION FILLINGS

Definition.—A combination filling is a filling composed of two or more distinct substances introduced into the cavity separately.

Objects of a Combination.—The object of combining various materials in the filling of a tooth's cavity is to secure a perfect filling, one possessed of all virtues and no faults. Many such combinations of material meet this demand in a large measure by bringing into service the strong features of each material, and at the same time nullifying the faults of all material entering into the construction.

Since dentistry has become a science, there has been a diligent search to discover a filling material which might possess the virtues of all and the faults of none in present use. At the present time this is more nearly reached by the various combinations possible with the usual distinct materials. If, perchance, the ideal filling is ever produced, the methods of procedure in dentistry will at once become much simplified.

Single Materials Used as a Filling.—There are only two filling materials now in use which are used in their pure states, pure gold and pure tin, and there are many instances where these combined with each other or with other materials will produce better results than when used alone.

Gold and Tin Combination.—This combination is of service in large cavities of Class Two which are subgingival and in large occlusal cavities in molars where the pulpal wall is deep and rounded. In this combination the tin should be placed in the cavity first and thoroughly condensed, and the filling completed with cohesive gold.

In Class Two the tin should cover the gingival wall at least one millimeter deep and be condensed to place with the matrix in position.

Benefits Derived.—Dentine upon which has been built a thoroughly condensed tin filling does not readily decay. By completing the filling with gold the discoloration of tooth substance is avoided and the gold will better resist the force of mastication.

Gold and Cement.—The object of this combination is to produce a filling that is adhesive, that will protect weak walls and resist the fluids of the mouth and the force of mastication.

Two Methods of Combining.—There are two methods of producing this combination. One is to cast the filling and lay it into the cement-covered cavity, which is the inlay method. The other is to build cohesive gold into a thin mix of soft cement with which the walls of the cavity have been coated. The essential feature of both is that the cement be completely covered to protect it from dissolution of external agencies, such as the fluids of the mouth and the effects of wear.

When Indicated.—The inlay combination is indicated in large cavities of easy access. The built-in method of combination is indicated in small cavities of more difficult access, and where correct cavity formation is impossible or ill-advised. When using this method, convenience angles may be omitted.

Gold and Platinum.—This combination adds to the many virtues of cohesive gold fillings by increasing the resistance of the filling to the wear of mastication. The pure gold is first used as it is capable of more perfect adaptation to the walls, all of which should be covered before taking up the platinized gold. The contour portion should be made of the alloy. This alloy comes from the supply house in sheets which appear to be pure gold except that the color is a little lighter. This foil comes in three numbers, 1, 2 and 3, the No. 2 being preferable for moist cases.

The rules for condensation are just the same as for pure gold, only the observance of each specific rule given on that subject is more emphatically demanded here, and when strictly followed the alloy will prove as easily handled.

Cohesive Gold and Noncohesive Gold Combined.—By this combination much time is saved as the noncohesive gold may be introduced in greater masses than the cohesive. Also the soft gold is more easily adapted to the walls than cohesive.

The cohesive gold is used to finish the contour as it will better resist the torsion strain and the effects of abrasion. Before the introduction of cohesive gold all gold fillings were noncohesive but since the introduction of the former the art of filling teeth well with soft gold has rapidly declined, so that the making of an entirely noncohesive gold filling is now the exception.

Cement and Amalgam.—Results similar to what might be termed an amalgam inlay are produced by coating the prepared cavity with cement, and immediately burnishing into this fresh cement a portion of the amalgam. The enamel margins are rendered clean again by freshly cutting them with a chisel for their entire outline, and the amalgam filling is immediately finished in the usual way.

The Benefits.—This combination produces a filling with the virtues of an amalgam to which is added the adhesion of the cement and the protection of cavity wall from fracture and discoloration.

When Indicated.—This is indicated in most large cavities to be filled with amalgam where the walls are weak and thin and in cavities where insufficient retentive form is secured.

Cement and Porcelain.—Cement is combined with porcelain in the filling of teeth for the purpose of making the filling adhere. The porcelain protects the cement from dissolution.

Silicate Cement and Fused Porcelain.—Fused porcelain inlays may be set with some of the silicate cements to great advantage. The silicate filling materials which are at their best when mixed thin enough to be adhesive are those which can be used as a cement. In fact, some operators are using these materials for setting the gold inlay with seemingly good results.

Silicate and Gold.—Silicate may be used to face the gold filling for esthetic reasons. In filling Class Four cavities with the gold inlay by either one of the four plans, the wax may be cut out of the pattern so as to present a labial surface almost entirely of silicate. After these two materials are combined in this class of cavity, care should be taken that the incisal edge is of gold and particularly that the cavosurface angle on the incisal outline is protected by one-half to one millimeter of the cast gold. The cast should be made and set with oxyphosphate of zinc cement. At a subsequent setting the silicate face may be built in. A similar effect is produced with the bicuspids and molars, in crown work. The gold crown is made in the usual way and set. A carborundum stone is applied to the buccal surface and ground away and a sufficient amount of

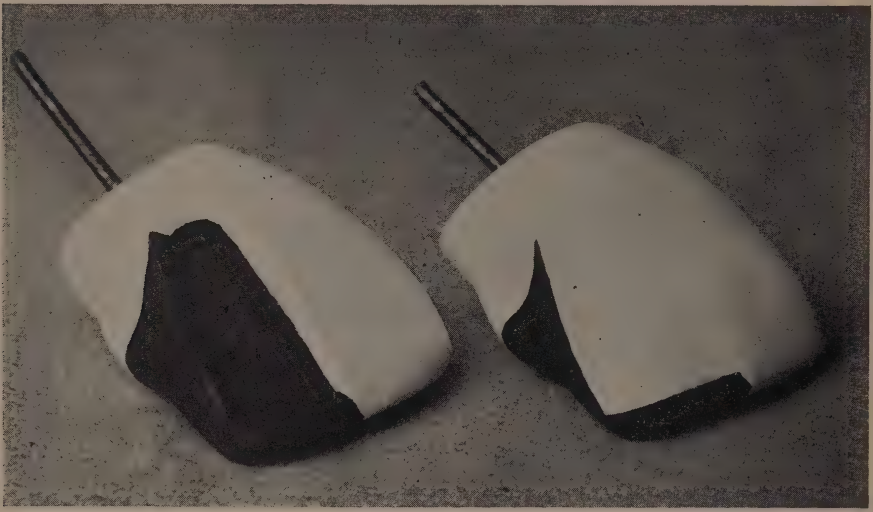

Fig. 164.—Combination gold inlay and silicate. *A* represents the gold inlay in position ready to receive the silicate. *B* represents the same after the silicate has been put in place.

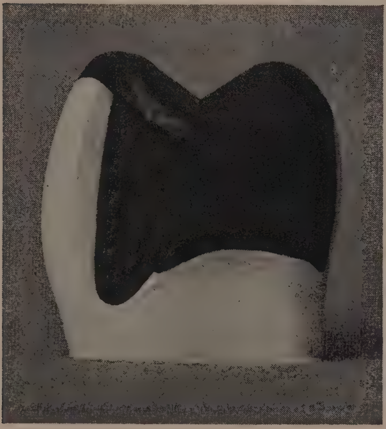

Fig. 165.

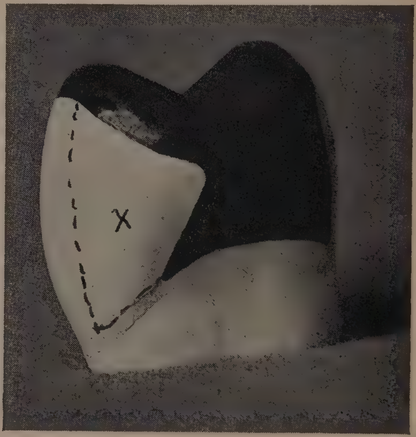

Fig. 166.

Fig. 165.—Amalgam in position ready to receive a partial facing of silicate.

Fig. 166.—This represents the amalgam filling shown in Fig. 165 with the silicate facing built in. The dotted line shows the outline of the silicate with that portion marked *x*, representing the silicate.

cement is cut out to make room for the building in of the silicate. Before building in the silicate it is best to coat the cement which is exposed within the crown with a thin application of cavity lining.

Silicate and Amalgam.—Many large contour amalgam fillings on the mesial surfaces of bicuspids and molars, particularly in the superior teeth, are unsightly. A very pleasing effect is produced by cutting away the mesiobuccal contour of amalgam, either in new or old fillings, and by building silicate in the resulting cavity. The silicate will not discolor when thus applied to the amalgam. Each individual case seems to require a different shade, however, and a trial mix should be made before deciding on the combination of powder to produce the desired shade.

Silicate as Applied to Prosthetic Work.—It is not within the scope of this book to deal with prosthetic procedures. However, it is well to call attention to the advantageous use of this material in the facing of crowns and the fitting of gingival ends of porcelain pin crowns to the root, and to its application to many places in pieces of bridgework. It is also useful in the facing of partial and full removable dentures in a color to imitate the natural gum tissues.

There are many other combinations which are made and used to advantage in tooth salvage. It is improbable that the perfect filling material will ever be produced as the demands are so varied in different mouths, and in different localities in the same mouth.

We are more nearly able to meet all of those varying conditions by a wise selection of the materials to be used in each case, and a judicious combination will go far to produce the perfect filling for each individual cavity as presented.

CHAPTER XXXV

PERIODONTOCLASIA

Definition.—The word pyorrhea is of Greek origin and means a discharge or flow of pus. Pyorrhea alveolaris is a generic term used to include various inflammatory conditions of the periodontal tissues but commonly understood to mean suppurative inflammation of those tissues. It is also called Riggs' disease, Fauchard's disease, interstitial gingivitis, periodontoclasia, etc. (Anthony).

The public has become familiar with the term pyorrhea and will willingly accept a diagnosis of any of the many gum lesions as such. The profession is not entirely clear on this point. In the chain of pathologic conditions, from simple inflammation of the gingival margins to the complete loss of the tooth-supporting structures, there seems to be no agreement as to when pyorrhea begins, or when that term does not describe the disease present.

There is probably no human ailment about which there is such a lack of agreement as to what it is and when it is present, and as to its etiology, diagnosis, clinical symptoms, treatment, and prognosis.

Limitations.—Since there is no common agreement as to what is pyorrhea, we will here consider the disease as periodontoclasia, comprising those oral diseases which may have their mutual manifestation in a simple gingivitis and may end in tooth exfoliation, and are not due to a specific bacterium. There is no one bacterium which we accept as pathognomonic. The bacteria accompanying the disease are incident, rather than causative, and no one bacterium is uniformly present which may not be found in seemingly healthy mouths.

Etiology.—If the disease was caused by a known germ, its prevention or cure could be more easily found, but the etiology is not as yet established to a degree of common acceptance. It would seem, however, that the expressions of the disease are many, that the clinical manifestations are varied, and that the causes are equally numerous, being both local and general.

The local causes may be either trauma, overuse or disuse, faulty occlusion, subgingival tooth decay, either primary, or secondary at the gingival margins of fillings, or continued chemical and mechanical irritation.

The traumatic causes may be poorly fitted gingival bands, overhanging fillings, or open or faulty contact points in the proximal spaces, permitting food impactions and injury by poor dentistry.

Overuse of a single tooth may be brought about by its employment as an abutment for a bridge, or a rest for a clasp in a removable partial denture, by the holding of a pipe for hours at a time when moving about, and by other forces when applied at an angle to the long axis of the tooth.

This form of the disease will show much bone absorption and preternatural mobility of tooth or teeth, yet with periodontal membrane attached at or near the cervix.

Disuse.—When a full complement of teeth is brought to tight closure, each tooth should strike its opponents with quite equal pressure. This is made possible by a provision of Nature which causes the erupting tooth to advance more or less rapidly until it receives the often repeated contacts in mastication.

Function stimulates root formation and the strengthening of the supporting structures. Failing to meet this stimulation at the proper height in the arch or being robbed of it later by the extraction of its opponents, produces the reverse condition, and we have tooth protrusion either posterior or anterior, resulting in weakened tooth support mechanically and physiologically.

Faulty occlusion as distinct from overuse is a term used to designate that resulting tooth force which is unnatural as to direction and amount and is most effective in producing the disease when received at an angle to the long axis of the tooth.

Subgingival decay is not infrequently the cause of periodontoclasia about a single tooth. This decay originates between the crest of an already unhealthy gum and its attachment, either as a primary decay or along the gingival margin of a filling, most frequently a gold inlay.

Chemicals as the primary cause are not now so common as in former days, as the public and the medical profession have learned of the dangers of mercury, lead, and phosphorus when preparations of these metals gain the blood stream. Mention should be made of the presence of the acids of food decay.

Mechanical irritation is without doubt the most frequent local cause as applied to each individual tooth as well as to the denture as a whole. The most destructive mechanical irritant is an accumulating incrustation of calculus, either salivary or serumal or *both,* at first deposited in proximity to the gingivae.

Later, salivary calculus may so far encroach upon the gum tissue as to destroy the attachment of the dental ligament of the tooth, which is the vital step in tooth detachment. Serumal calculus is a deposit of lime salts from the blood stream approximating congested areas and is generally found on the roots of teeth overlaid with detached gum tissue of long standing.

General Cause.—The oral condition usually accepted as periodontoclasia may be a local expression of a general systemic disorder remote from the mouth.

It is quite an accepted fact that certain forms of the disease may be associated with such general disorders as faulty metabolism, malnutrition, faulty diet, diabetes, osteomyelitis, salivation, syphilis, and tuberculosis. When some general systemic condition is the predominating cause over the local active causes, the symptom in the resulting disease is a great amount of bone resorption, which leaves the gingival margins detached yet near the normal position about the tooth. Such cases are resistant to all means of local treatment, except surgery or packs. There may be an entire absence of tartar, yet in diabetics there may be deposits of serumal calculus on denuded cementum.

Treatment.—The treatment, as in all other ailments, consists in the removal of the cause, the assisting of Nature in an endeavor to bring the tissues involved back to normalcy, and the elimination of those habits in diet and oral hygiene which would be a direct causative factor for the return of the disease.

The foregoing statement, when applied to the early stages of the disease, describes a quite simple procedure, whereas in the advanced stages the loss of tooth-supporting structures and the tendency to return are ever a menace.

Bacteria Encountered.—As stated before, the bacteria always present are incident to the condition rather than causative. The conditions favorable to the development of the oral flora are found in all mouths at various times and in some mouths at all times. Microscopic examination of smears shows those most frequently found to be the *Entamoeba buccalis* and the Spirochaeta of which *S. vincenti* and *S. refringens* are the most common.

S. vincenti may be found in conjunction with a fusiform bacillus in a throat inflammation termed Vincent's angina. *S. refringens* is most frequently associated with the *Treponema pallidum* when periodontoclasia is in the mouth of a person positive to the Wassermann test.

In addition to the above we should be able to isolate various strains of streptococci which are among the organisms most frequently and abundantly found in plates made from normal buccal secretions.

All the various bacteria mentioned, while not a direct cause of periodontoclasia at any stage, must be reckoned with and, in so far as possible, eliminated, as their presence becomes a contributing factor.

Inasmuch as the mechanical procedure called for may produce abrasions of gum tissue, thereby subjecting the blood stream as well as the alimentary canal to new inoculations, it is advisable to use oral disinfectant precautions before taking up the usual instrumentation.

Local Treatment.—*Correct* overuse and disuse.

Correct dentistry that is irritating to the gingivae.

Correct faulty contact points, particularly in Class Two fillings.

Correct faulty occlusion.

Correct faulty fillings with gingival decay.

Prevent the absorption into the blood stream of the various preparations of lead, mercury, and phosphorus.

Calculus—Remove all calculus from the teeth by instrumentation, using a liberal number of x-rays to locate the deposits.

Pockets.—Remove all existing pockets early in the treatment. The obliteration of the pockets to the depth of the several attachments is fundamental. There are several means of pocket removal: First, the extraction of all affected teeth in advanced cases. Second, the extraction of every other tooth in the arch. Third, the burning away of the soft tissues with caustics. Fourth the excision of the gum portion of all the pockets about the teeth with knives or the diathermy knife (surgical treatment). Fifth, the packing of the pockets with what is known as a ''pyorrhea pack,'' covering same with adhesive tin foil which often completely eliminates deep pockets in forty-eight hours. This last method is less painful than the use of the knife and there is less danger of infection.

In cases of deep pockets on single-rooted teeth it is well to cease all medication as soon as the root is clear of tartar and the pocket of reactive tissue. Then, on visits of every other day, wash the pocket with the normal salt solution, and,

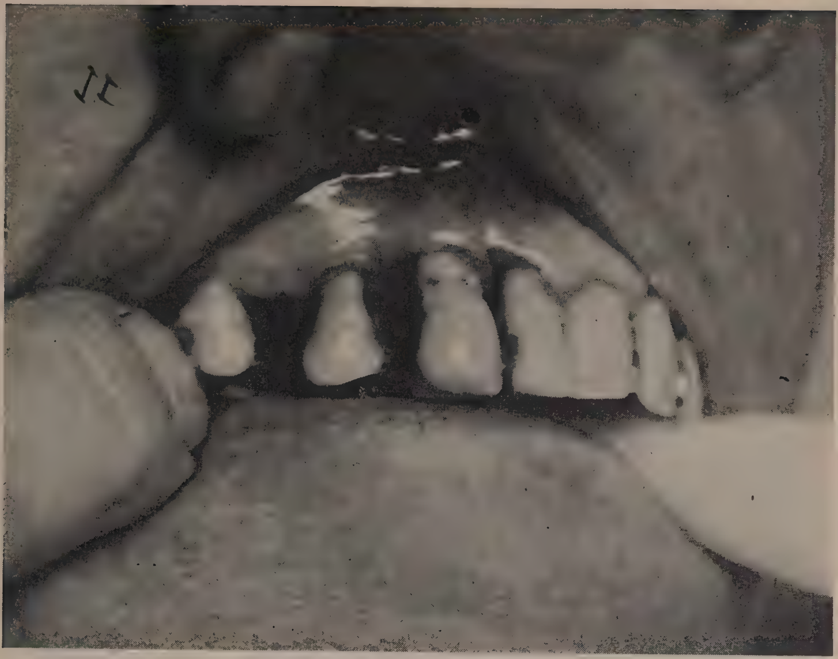

Fig. 167.—Case 286. Shows results following the extraction of every other tooth. By that means one side of each pocket is removed.

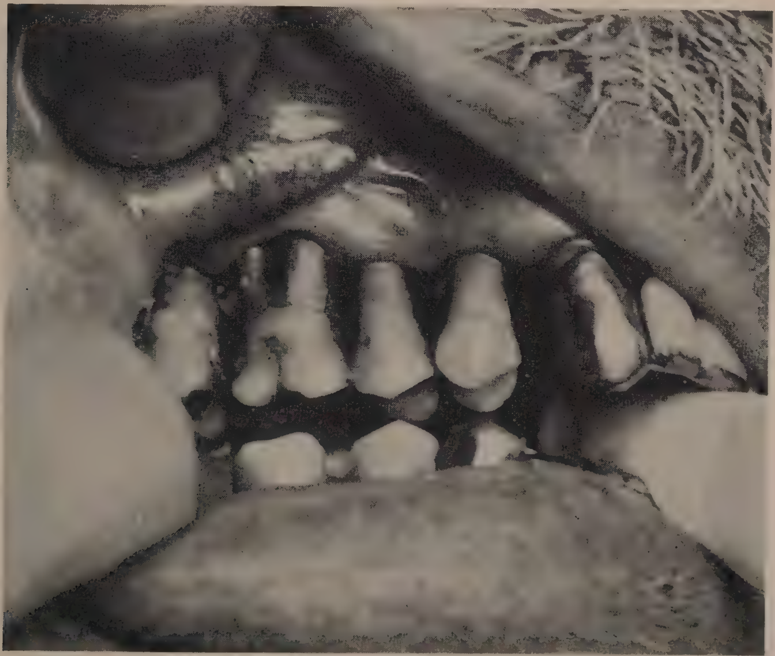

Fig. 168.—Case 285. After treatment. It would have been better to have extracted the molar.

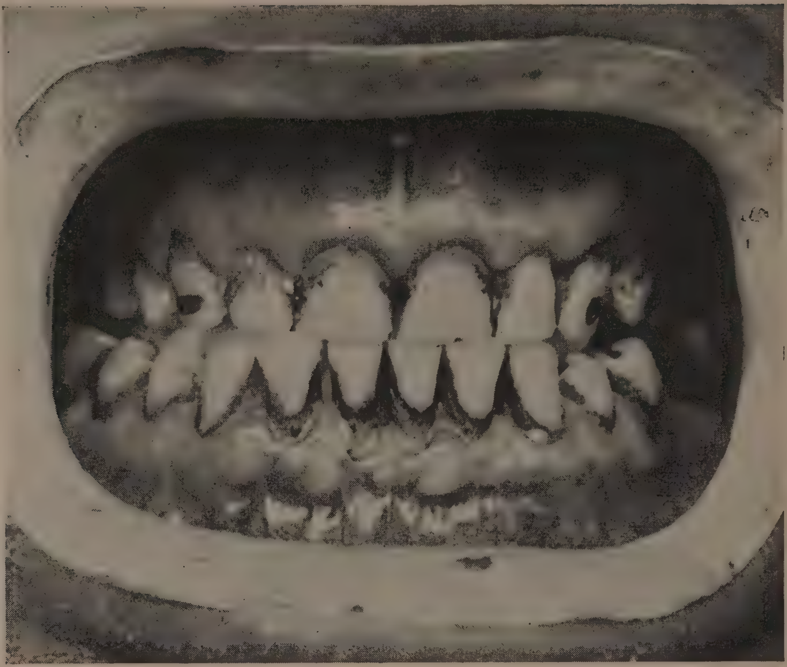

Fig. 169.—Case 284. Before treatment. Cleaning, medication, and home massage.

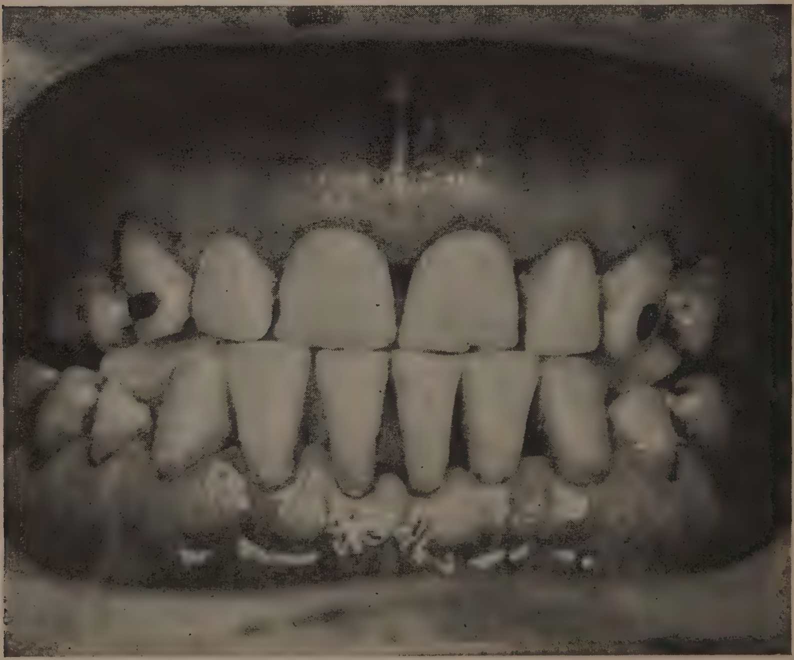

Fig. 170.—Case 284. After treatment.

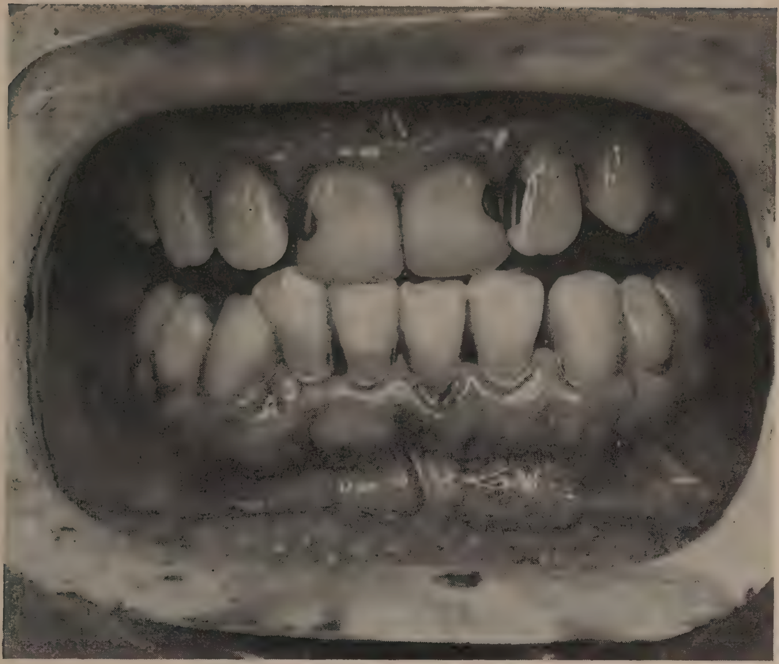

Fig. 171.—Case 282. Before treatment.

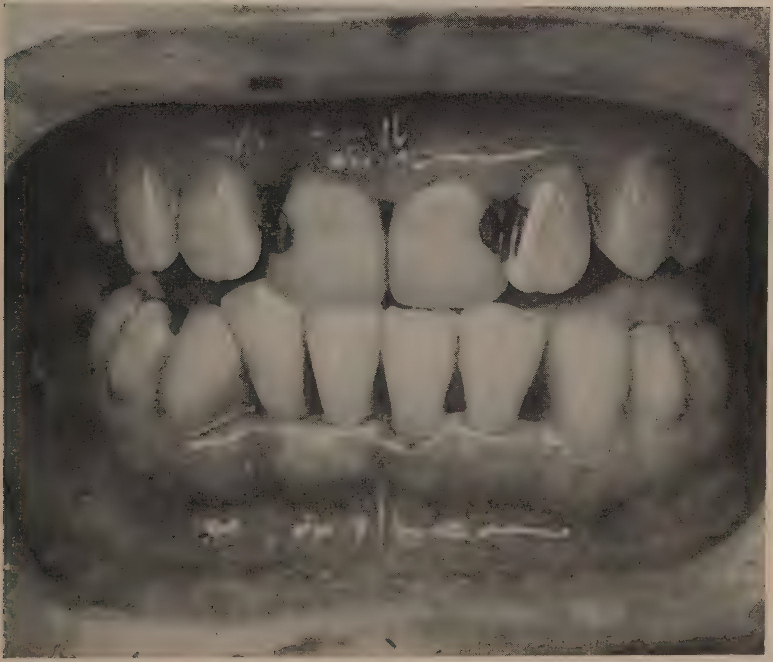

Fig. 172.—Case 282. After treatment.

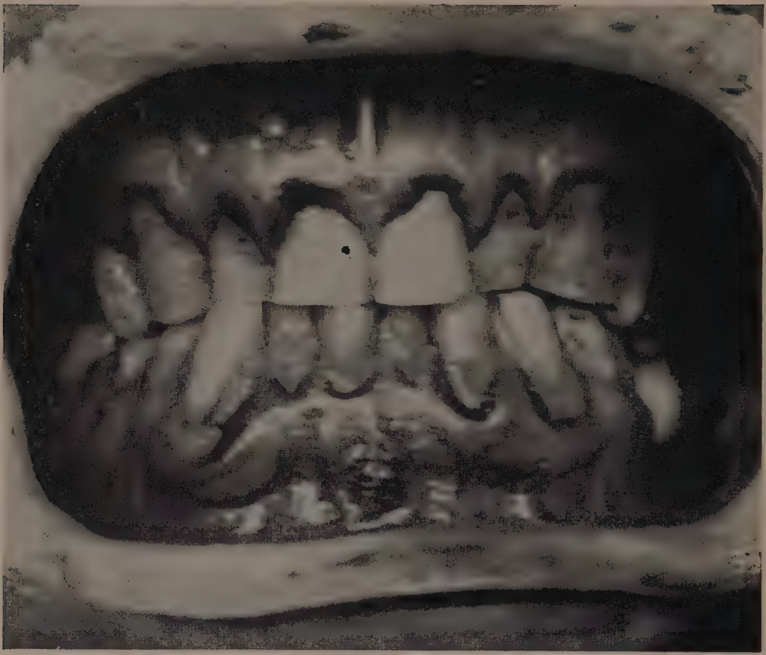

Fig. 173.—Case 281. Before treatment.

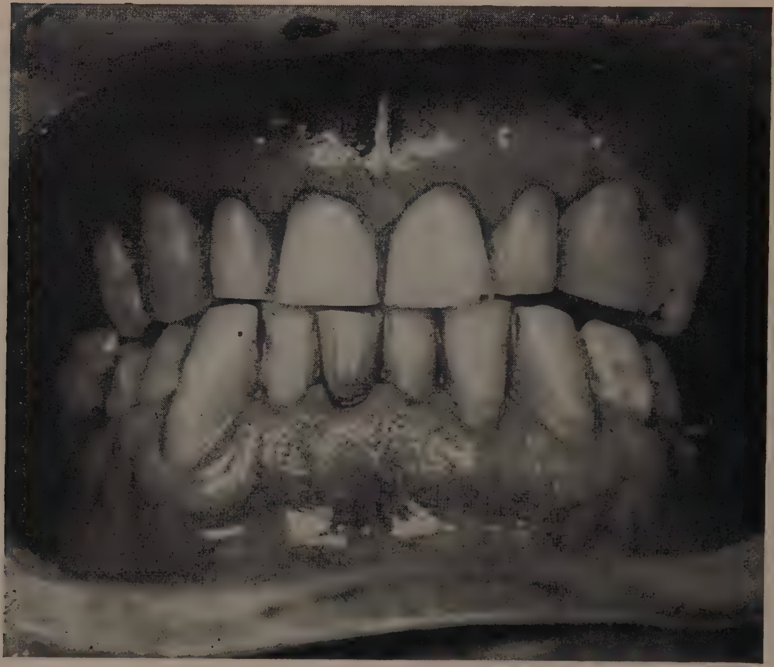

Fig. 174.—Case 281. After treatment.

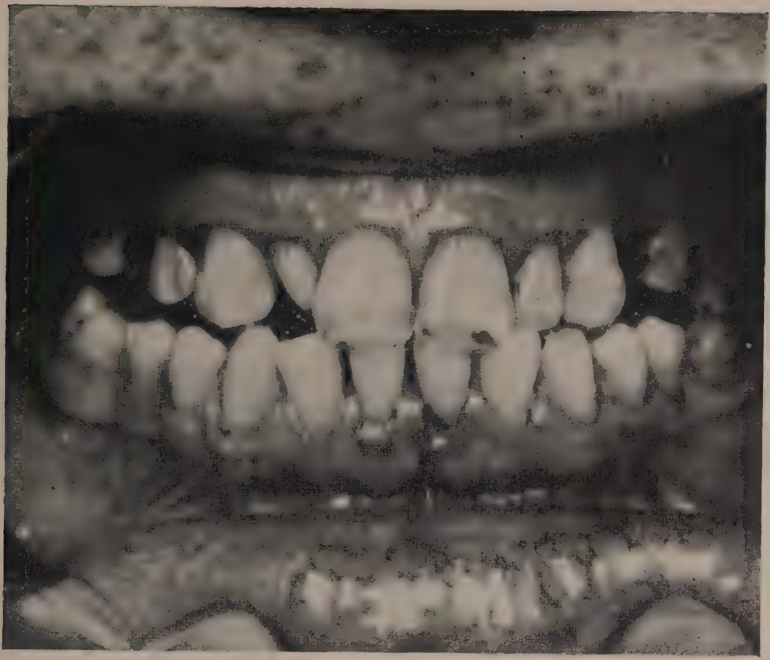

Fig. 175.—Case 276. Before treatment.

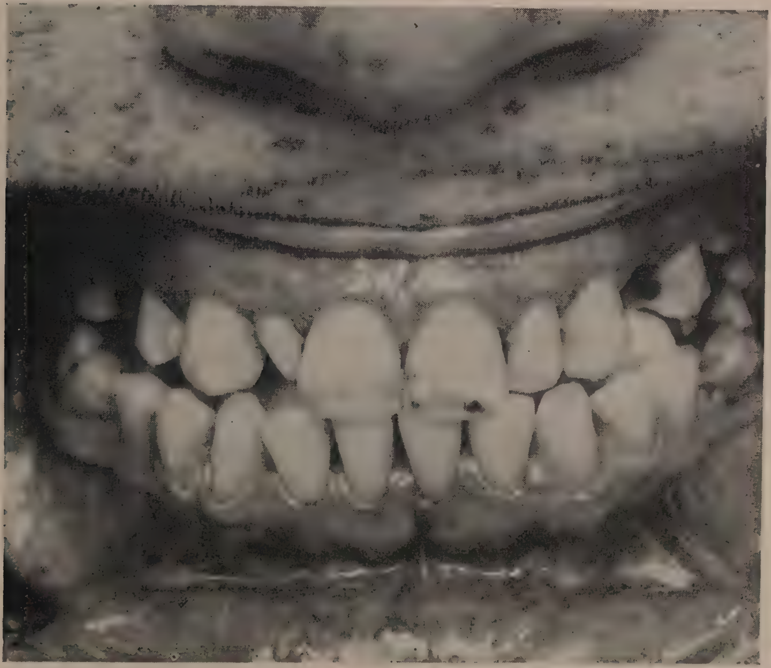

Fig. 176.—Case 276. After treatment. Note restored gingival margin. Patient used finger massage daily.

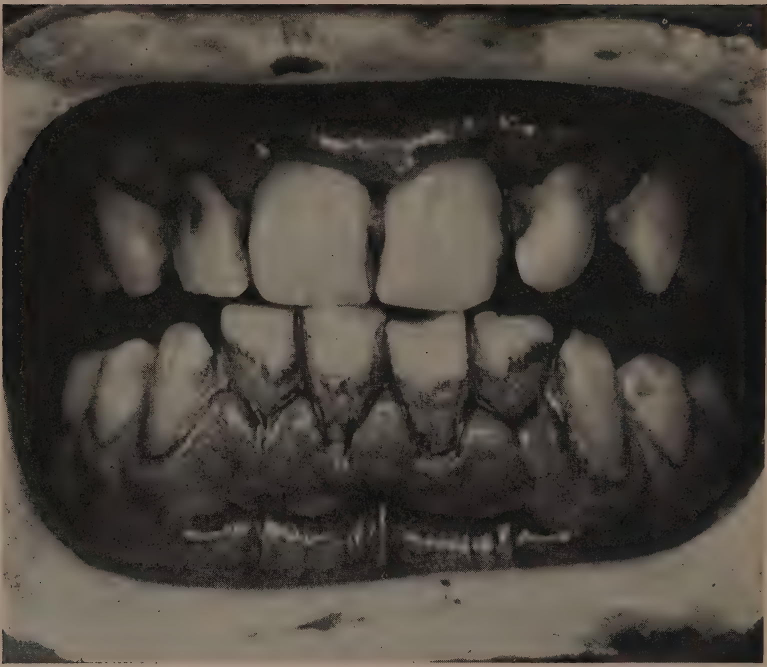

Fig. 177.—Case 275. Before treatment.

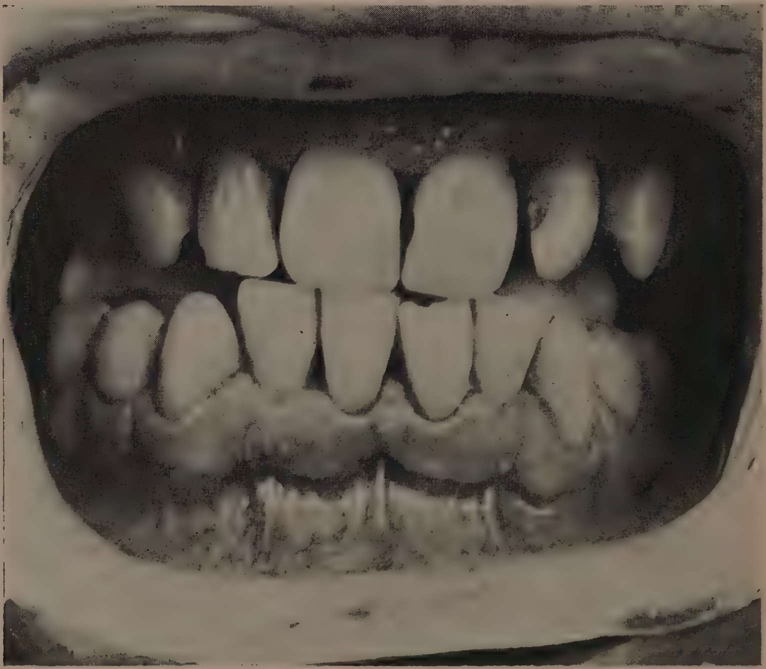

Fig. 178.—Case 275. After treatment.

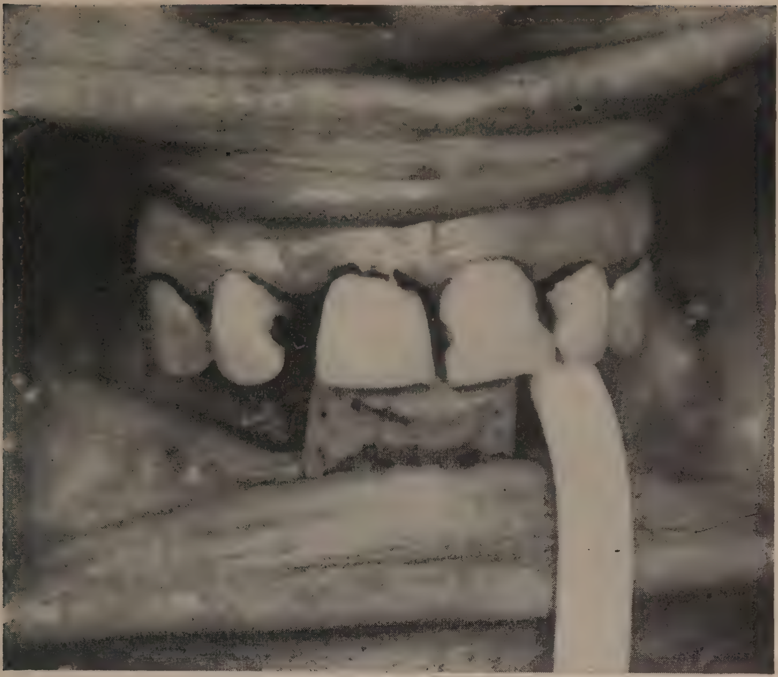

Fig. 179.—Case 274. Before treatment.

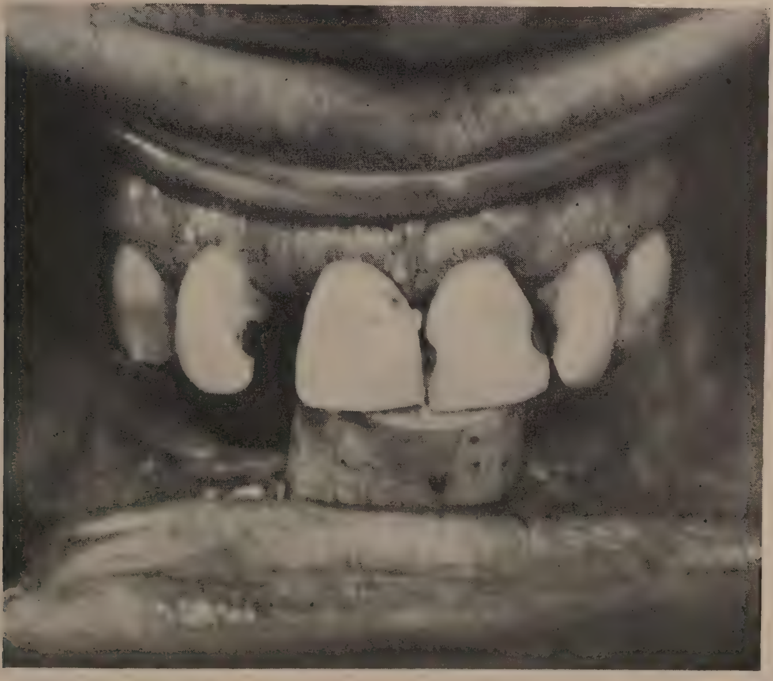

Fig. 180.—Case 274. After treatment.

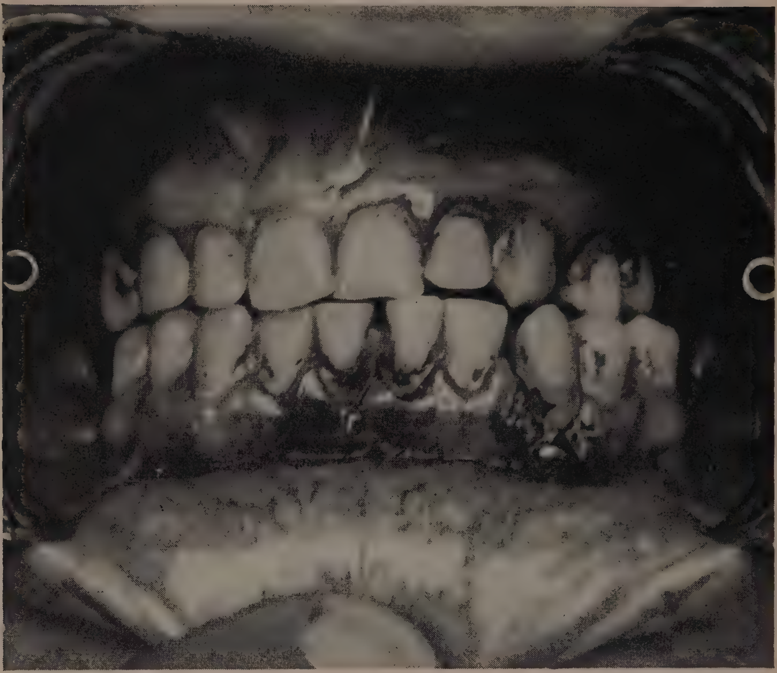

Fig. 181.—Case 270. Before treatment.

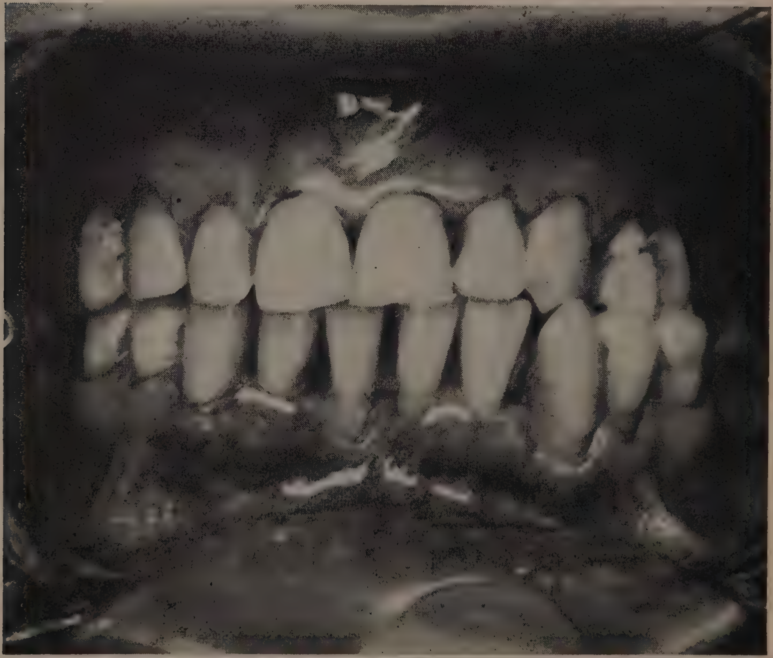

Fig. 182.—Case 270. After treatment. One application of trichloracetic acid, then stimulating drugs, and daily massage by the patient.

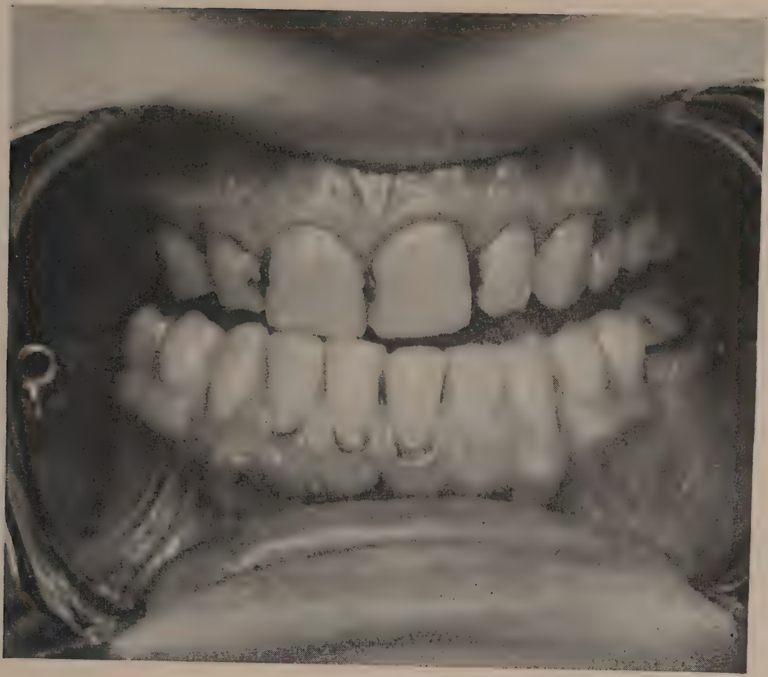

Fig. 183.—Case 269. Before treatment.

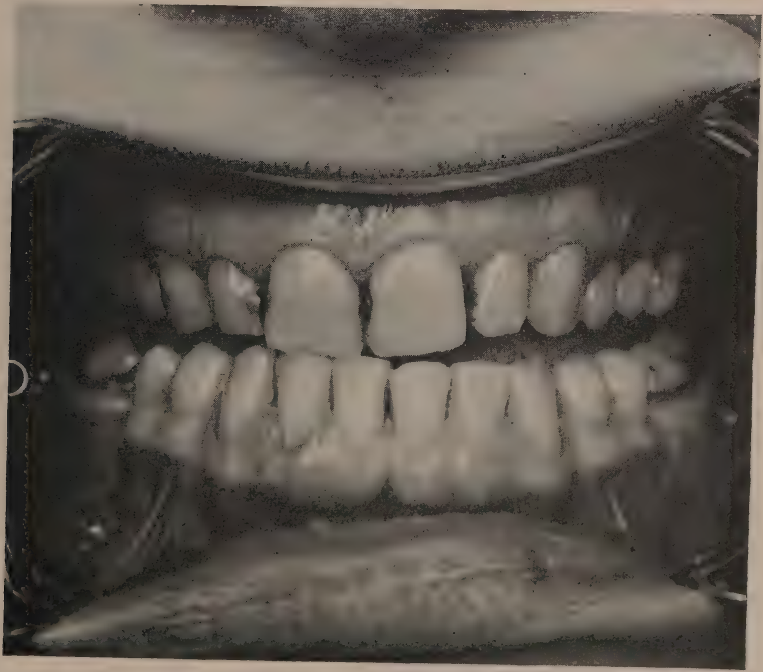

Fig. 184.—Case 269. After treatment. Care taken to destroy no tissue.

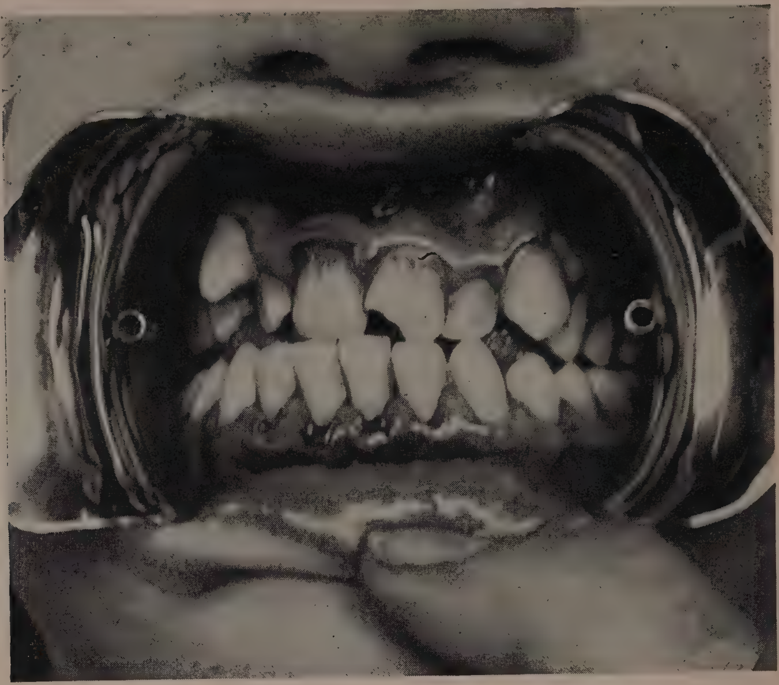

Fig. 185.—Case 268. Before treatment.

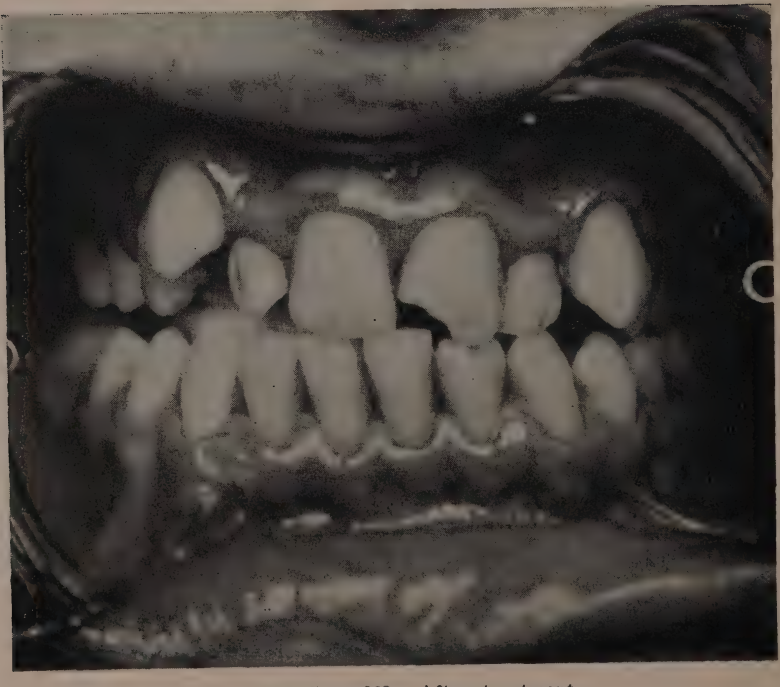

Fig. 186.—Case 268. After treatment.

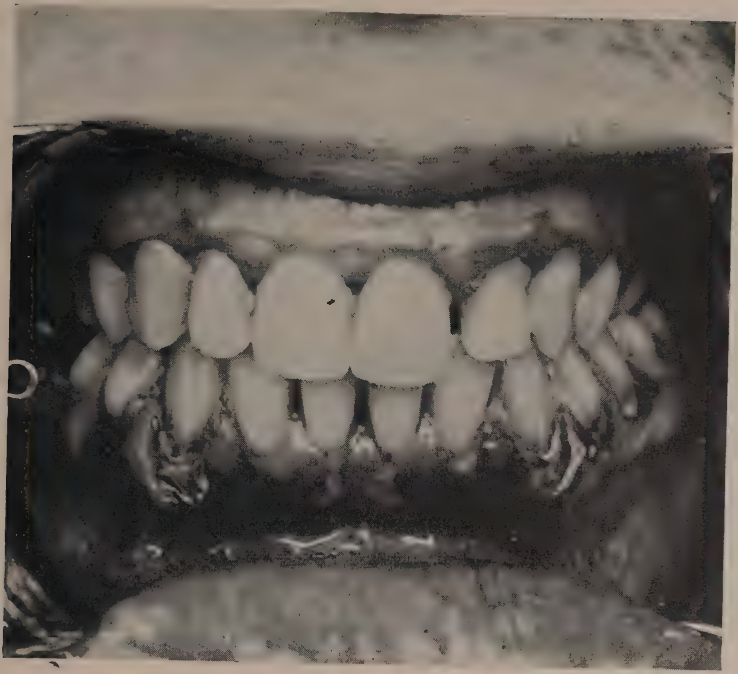

Fig. 187.—Case 266. Before treatment.

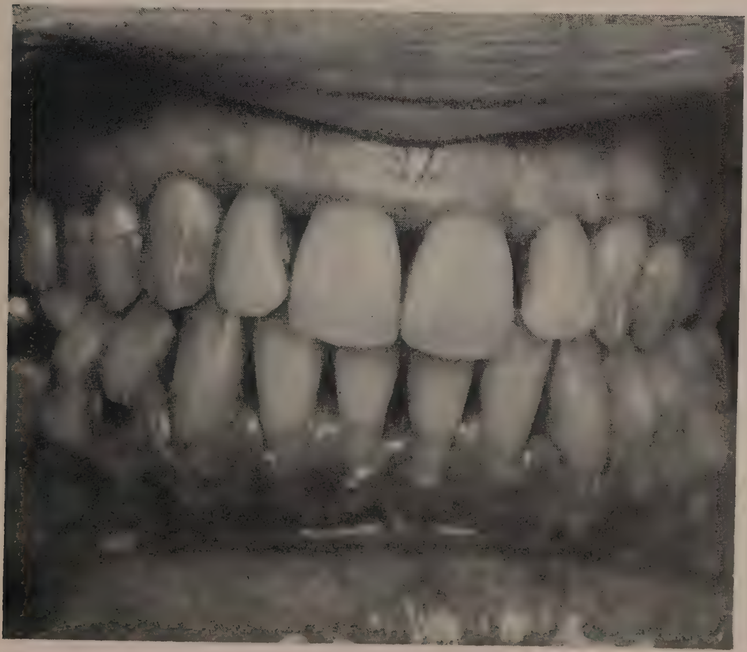

Fig. 188.—Case 266. After treatment. Uncompleted case.

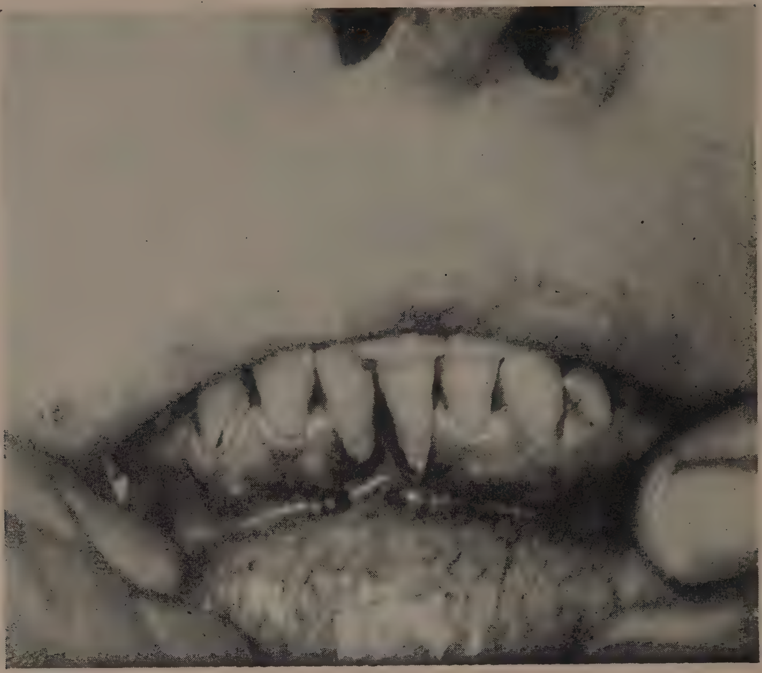

Fig. 189.—Case 258. Before treatment.

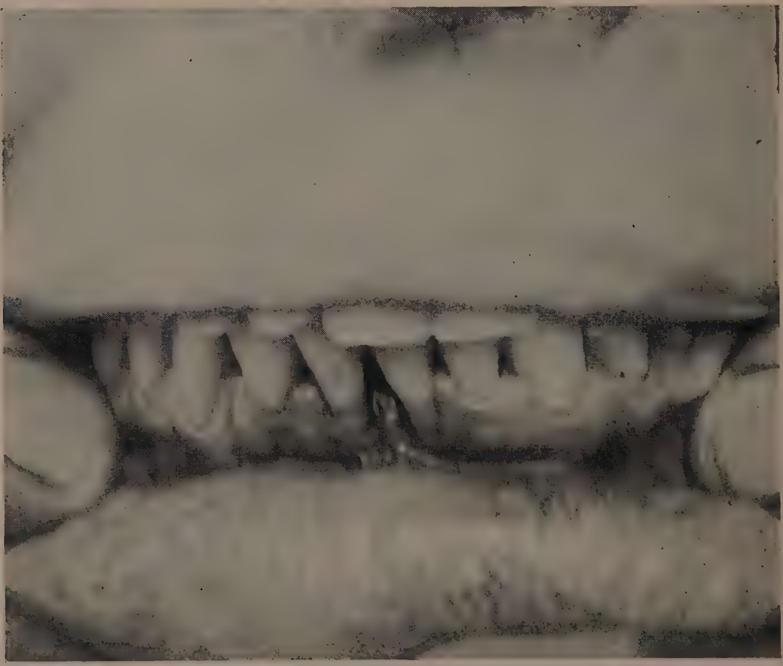

Fig. 190.—Case 258. After treatment. Lower frenum should be liberated.

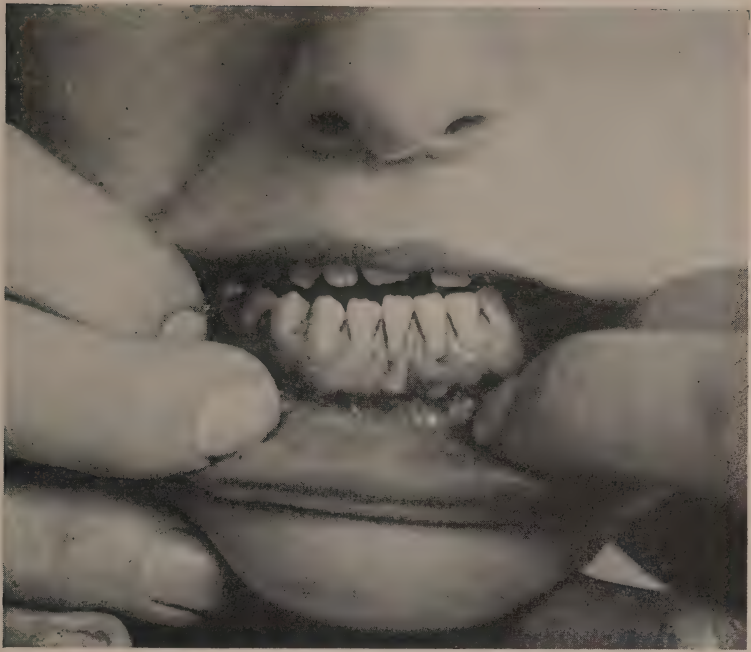

Fig. 191.—Case 256. Before treatment.

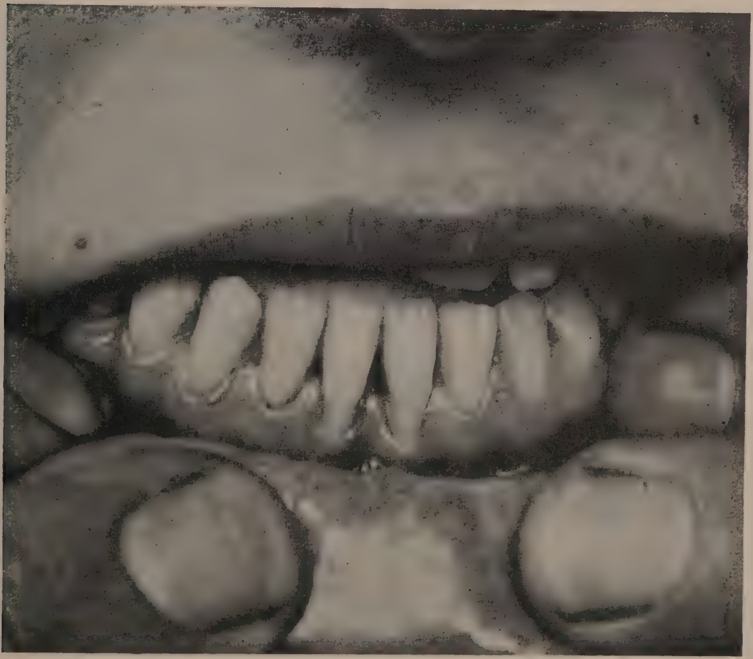

Fig. 192.—Case 256. After treatment.

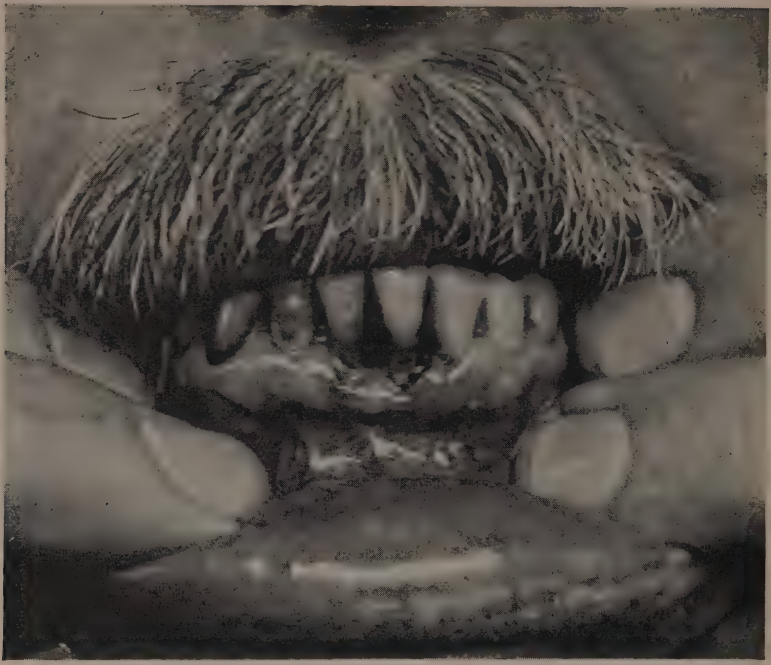

Fig. 193.—Case 254. Before treatment.

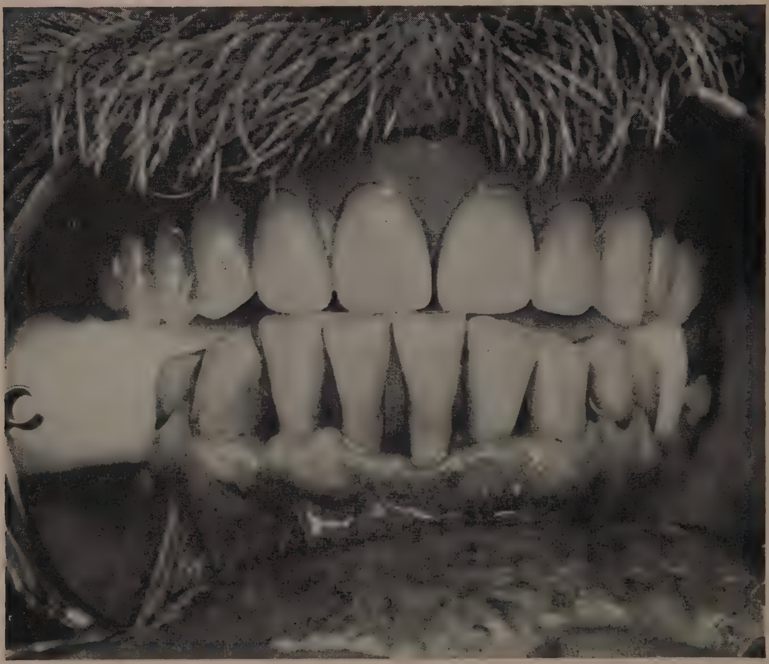

Fig. 194. Case 254. After treatment. Gum curettement used.

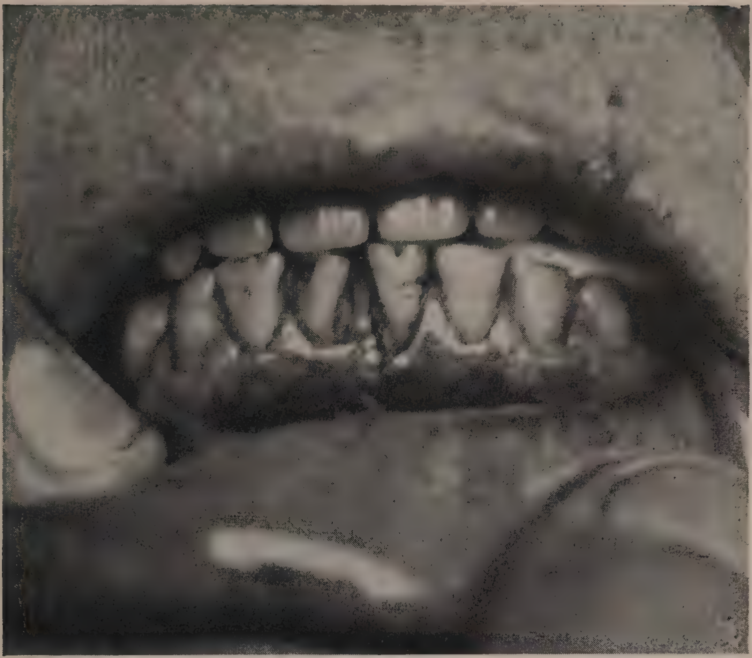

Fig. 195.—Case 230. Before treatment.

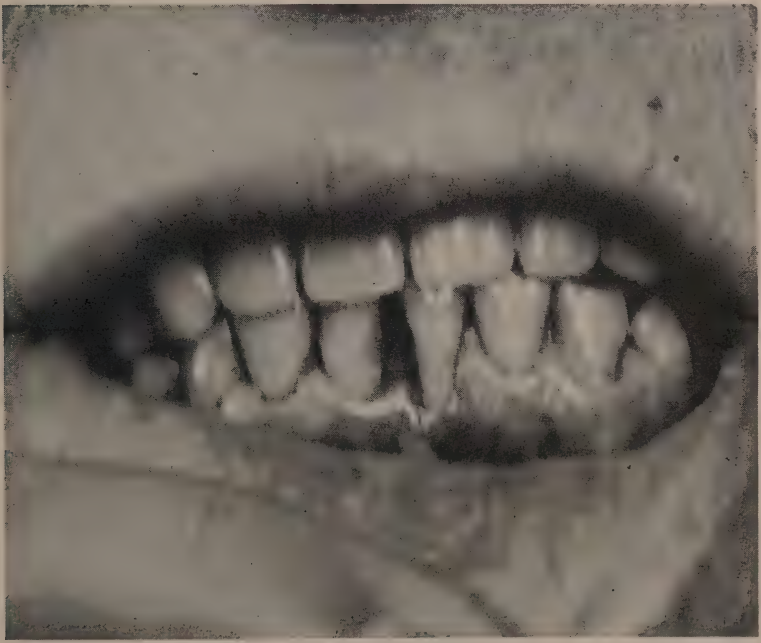

Fig. 196.—Case 230. After treatment.

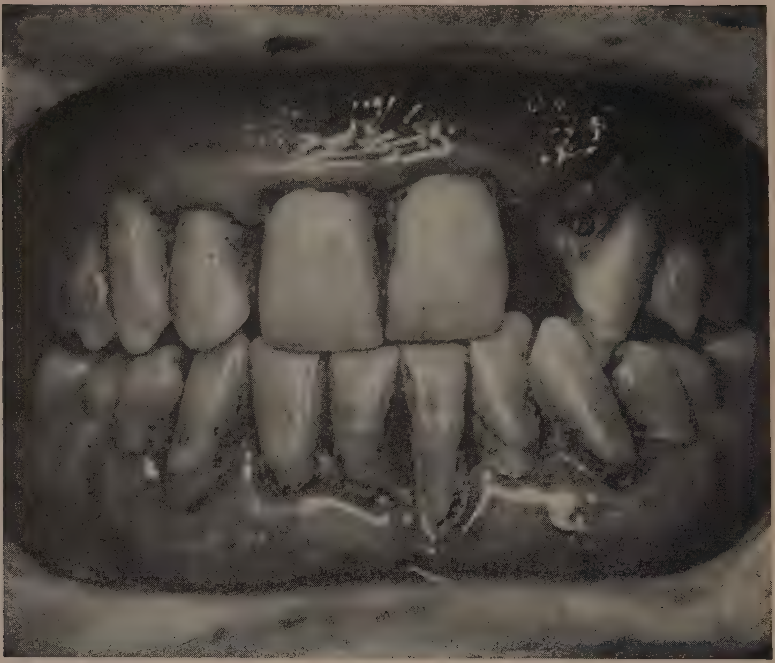

Fig. 197.—Case 219. Before treatment.

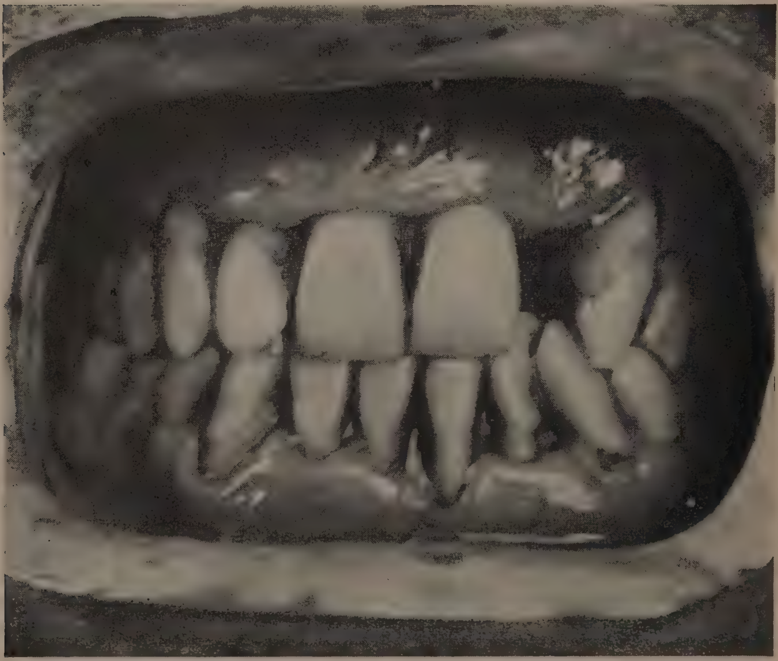

Fig. 198.—Case 219. After treatment. Note synthetic porcelain filling in left cuspid.

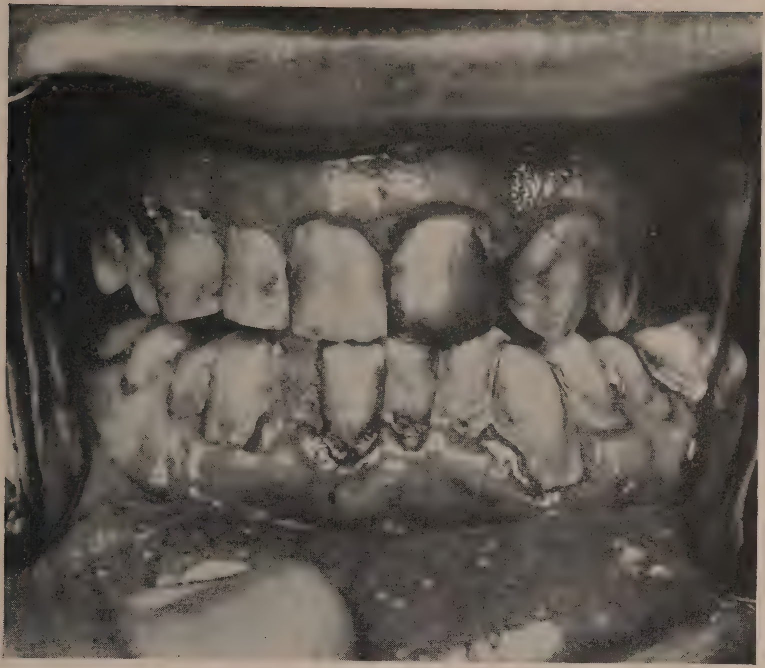

Fig. 199.—Case 217. Before treatment.

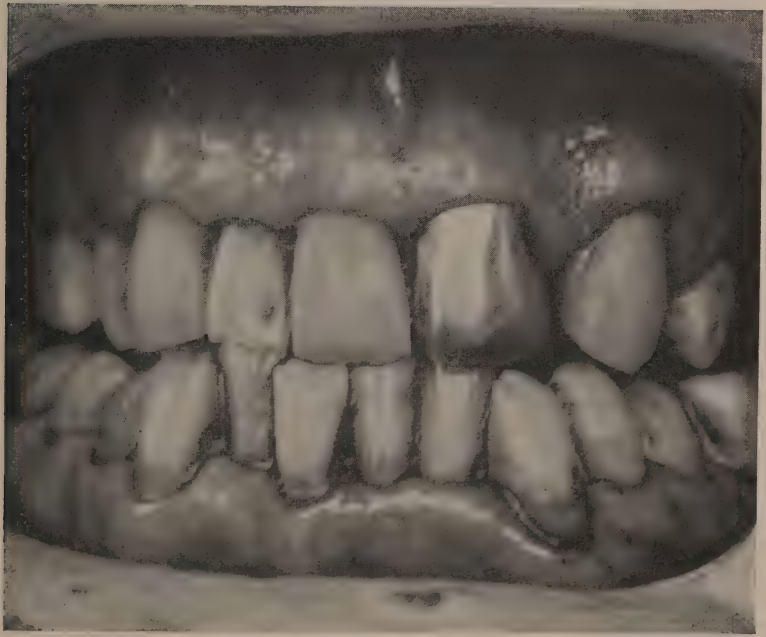

Fig. 200.—Case 217. After treatment. (The gold crown is not our trademark.)

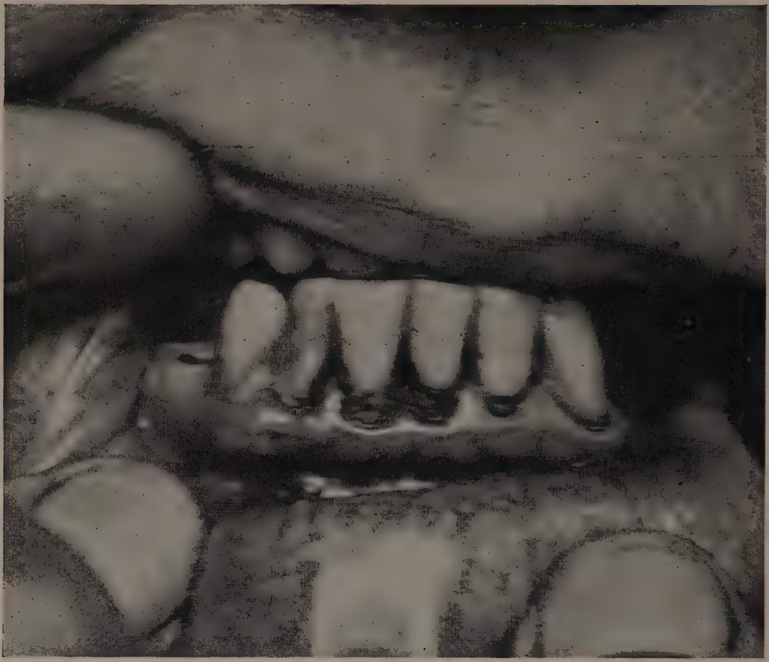

Fig. 201.—Case 216. Before treatment.

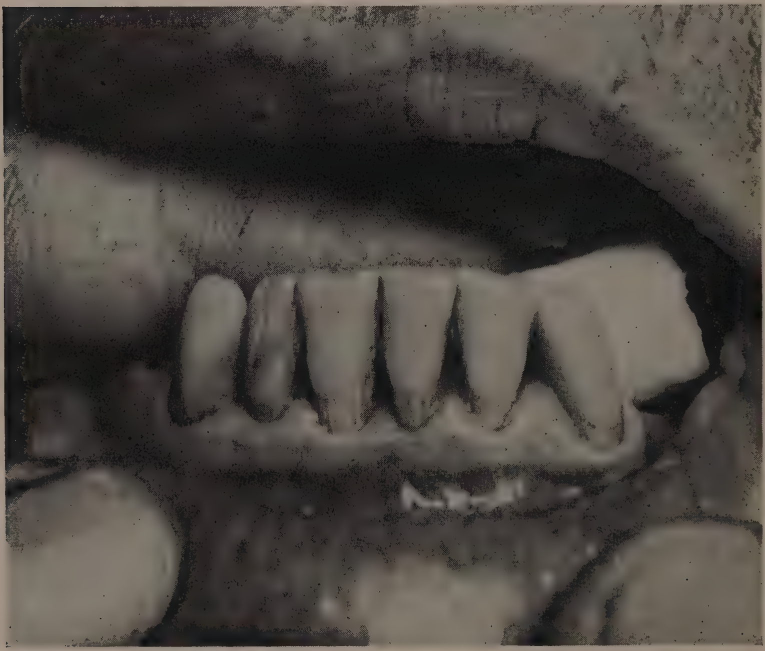

Fig. 202.—Case 216. After treatment.

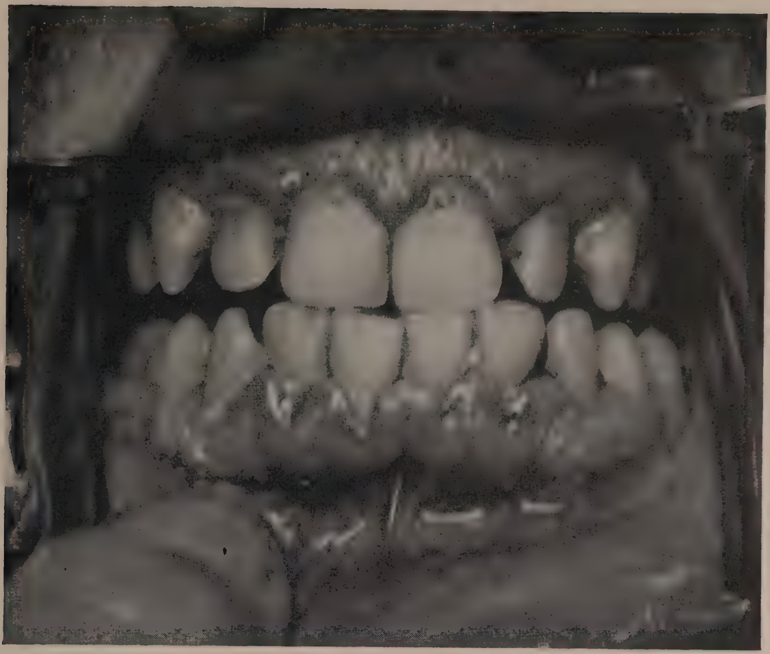

Fig. 203.—Case 212. Before treatment.

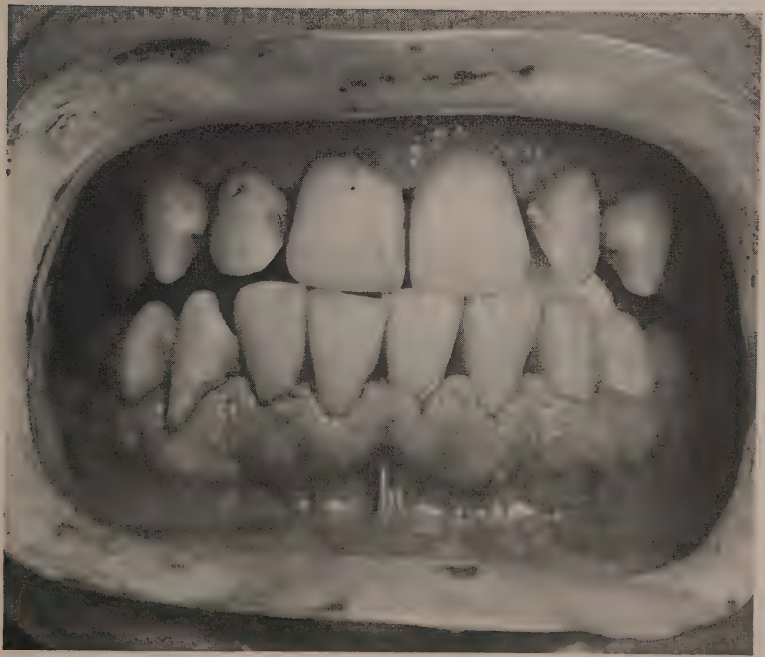

Fig. 204.—Case 212. After treatment.

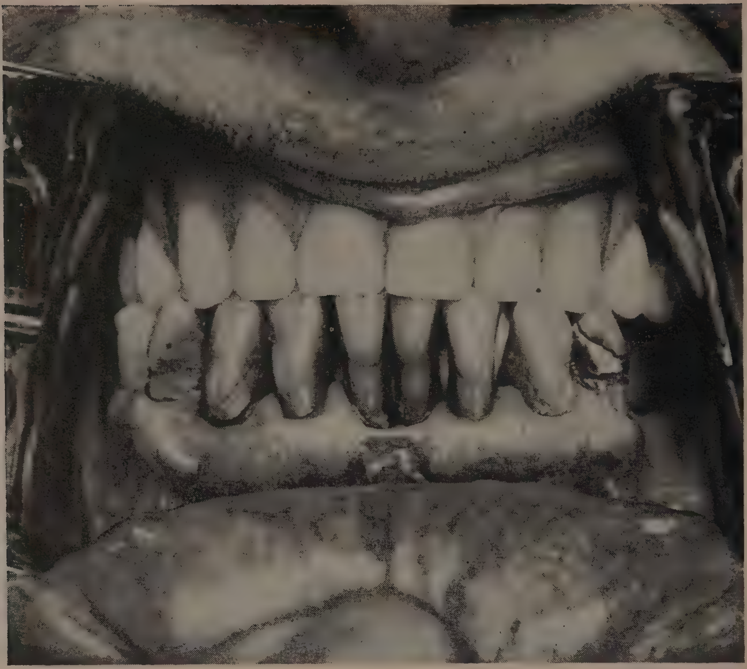

Fig. 205.—Case 211. Before treatment.

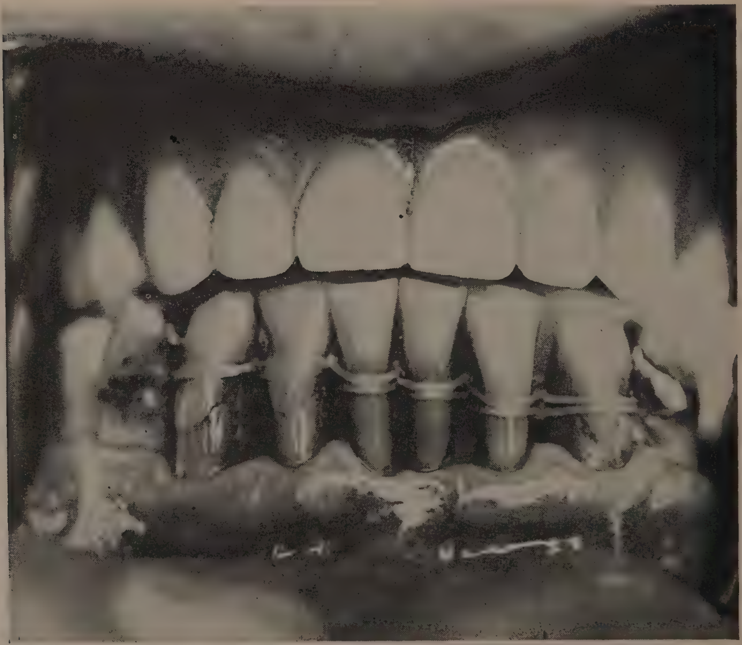

Fig. 206.—Case 211. During treatment. Case shows orthodontic ligature splinting. Also great loss of gum tissue as occurs with surgery or pyorrhea (periodontal) packing. Poor practice is shown on the six anterior teeth as the disfigurement is permanent.

by pricking the pocket from within near the bottom, cause the pocket to bleed and clot. This treatment many times results in a reattachment and a renewed bony septum.

With treatment carried to the above stage the symptoms and conditions usually designated as "pyorrhea" are eliminated for an indefinite time so far as local symptoms are concerned, except for the resulting deformity due to a loss of the soft tissues which entered into the formation of the pockets.

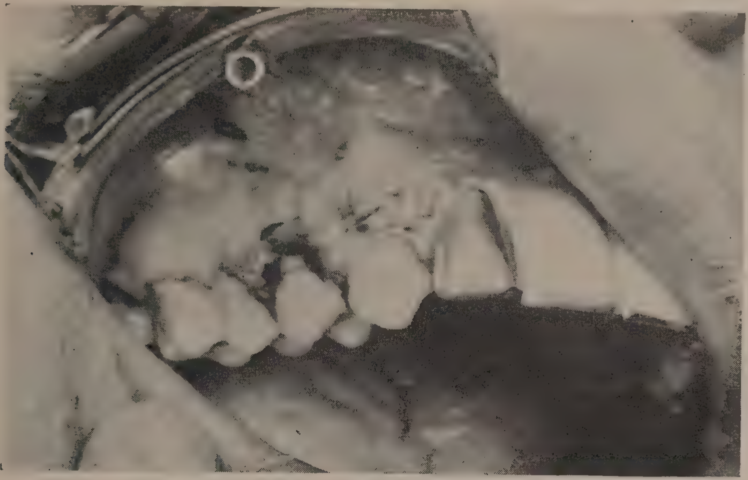

Fig. 207.—Case 207. Right side before treatment.

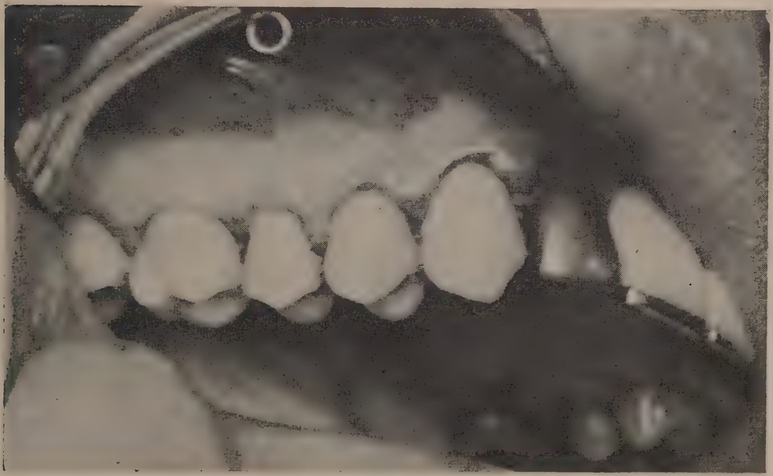

Fig. 208.—Case 207. Right side after treatment.

General Treatment.—When large pockets have formed and there is persistent recurrence with no great tendency to tartar deposits, general systemic treatment is called for in conjunction with the local treatment just outlined. In such cases the local symptoms are but the expression of general disorders.

This will call for the assistance of the general practitioner both as to examination and treatment. A thorough physical examination by the physician in general practice many times exposes the main contributing cause.

Certainly the treatment of such a condition is not in the limited field of a dental practice. The desire on the part of so many dentists to be known as surgeons is lamentable. The attempt of a dentist not in consultation with a physician, to treat general disorders by tooth extraction, as well as to practice internal medication, is ill advised and should be condemned.

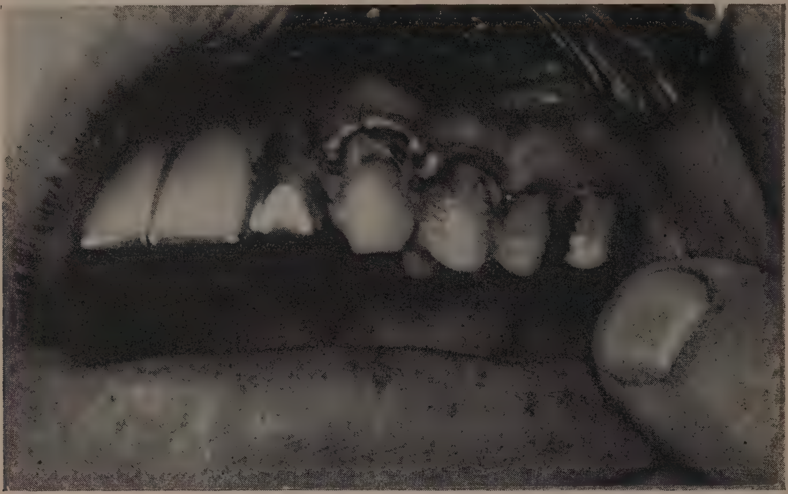

Fig. 209.—Case 207. Left side before treatment.

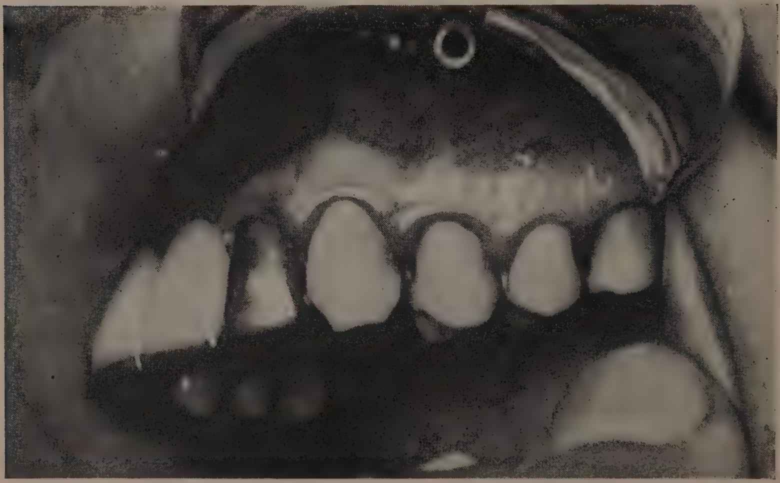

Fig. 210.—Case 207. Left side after treatment.

If the dentist stays within his own field, at the same time getting all the help possible from the physician as to the general diagnosis and treatment, he

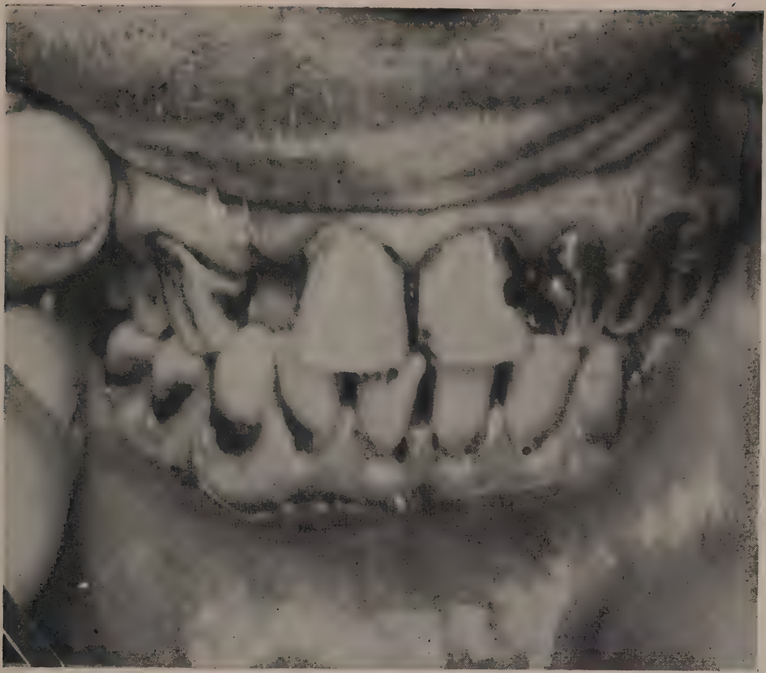

Fig. 211.—Case 206. Before treatment.

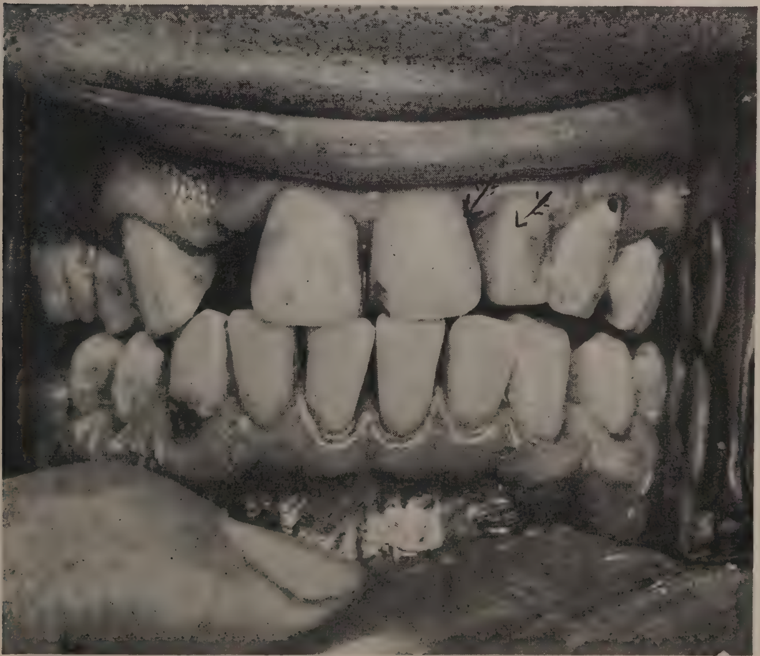

Fig. 212.—Case 206. After treatment. Note synthetic porcelain fillings of Classes Three and Four.

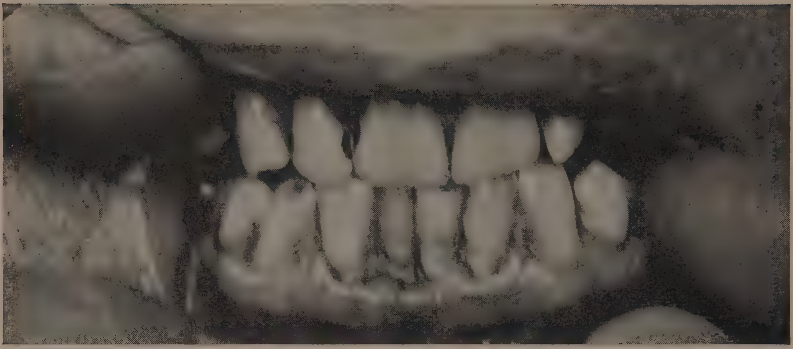

Fig. 213.—Case 305. Before treatment.

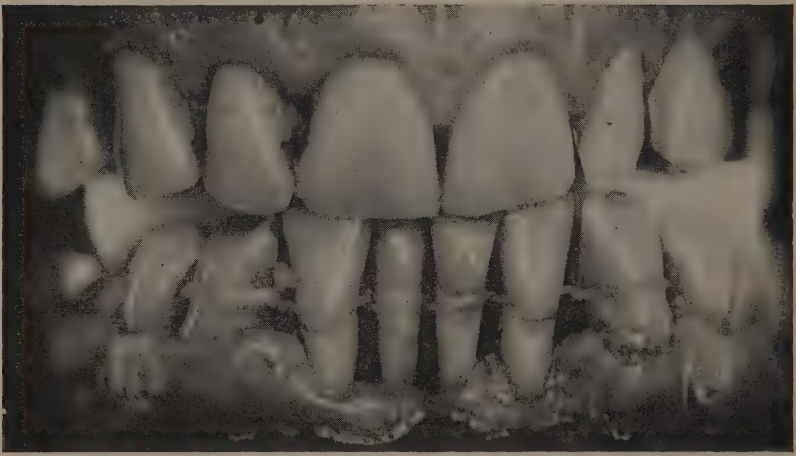

Fig. 214.—Case 305. Showing orthodontic ligature splint and the results of surgery or packing.

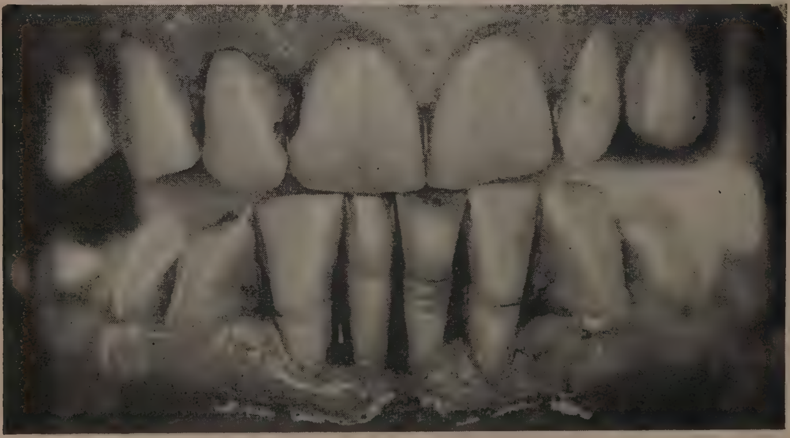

Fig. 215.—Case 305. After treatment.

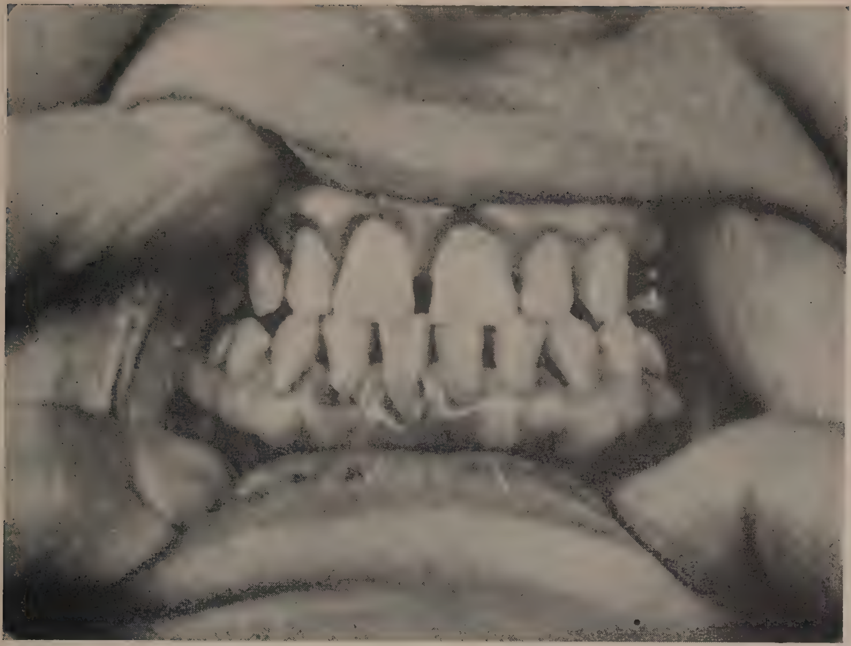

Fig. 216.—Case 203. Before treatment.

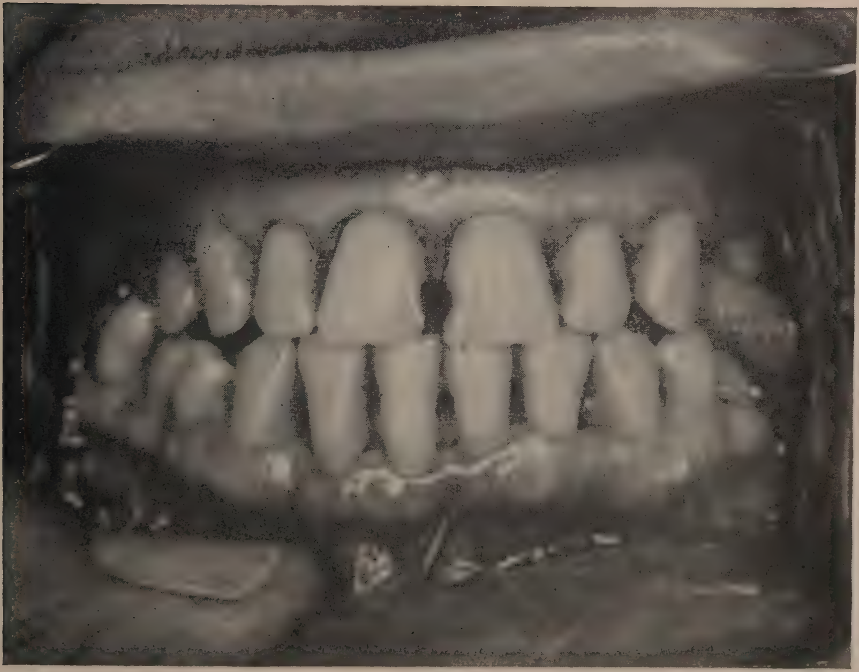

Fig. 217.—Case 203. After treatment.

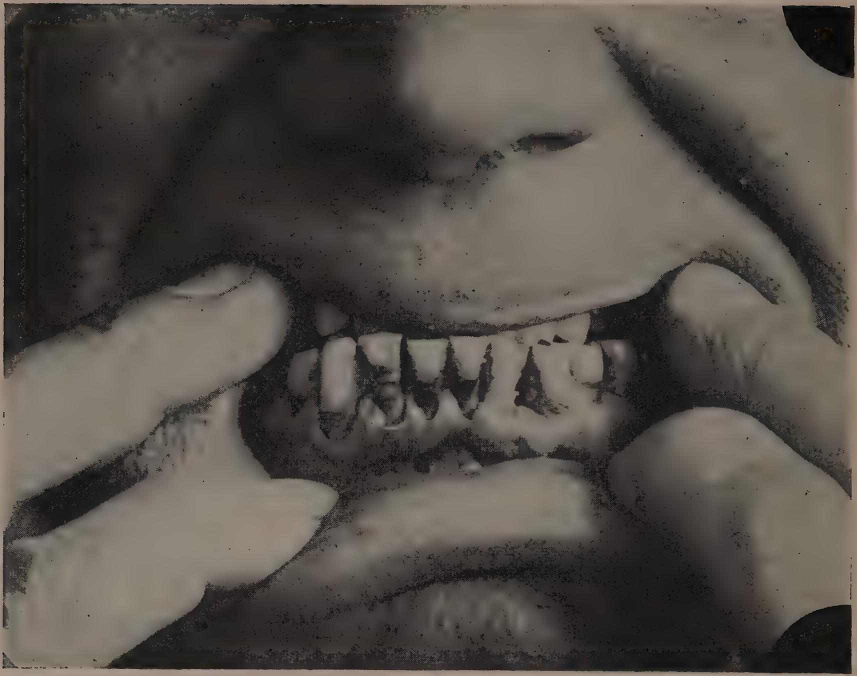

Fig. 218.—Case 202. Before treatment.

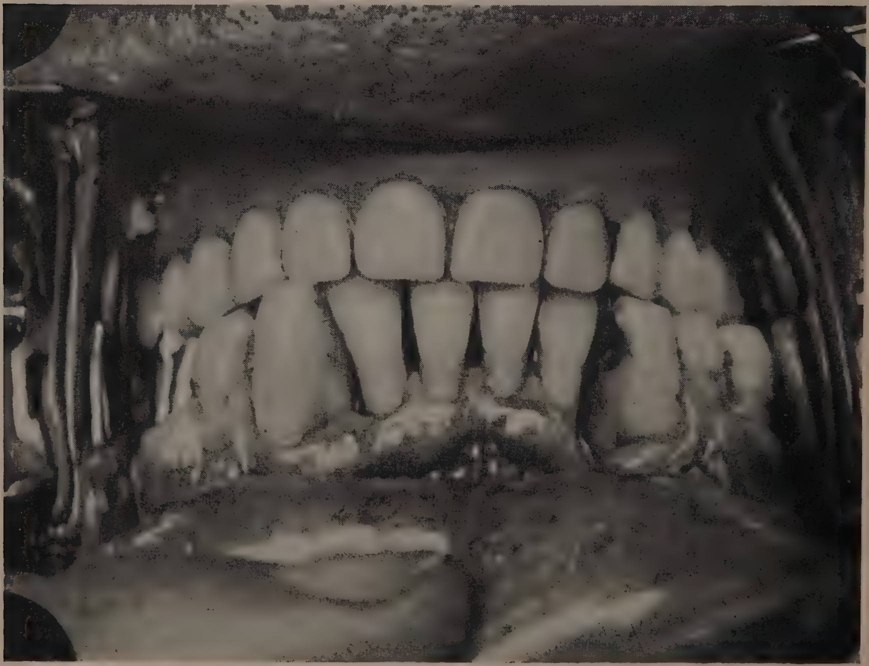

Fig. 219.—Case 202. After treatment.

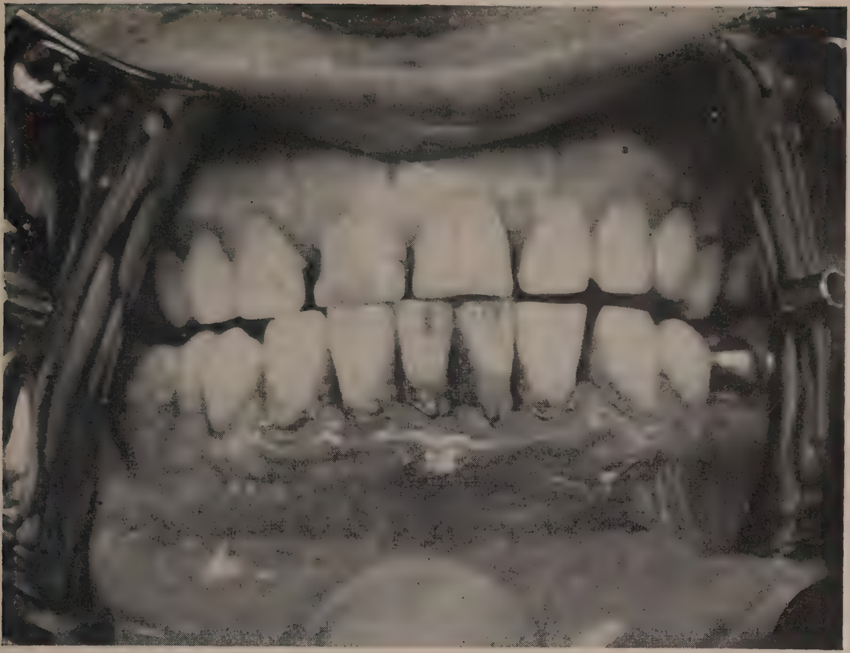

Fig. 220.—Case 201. Before treatment.

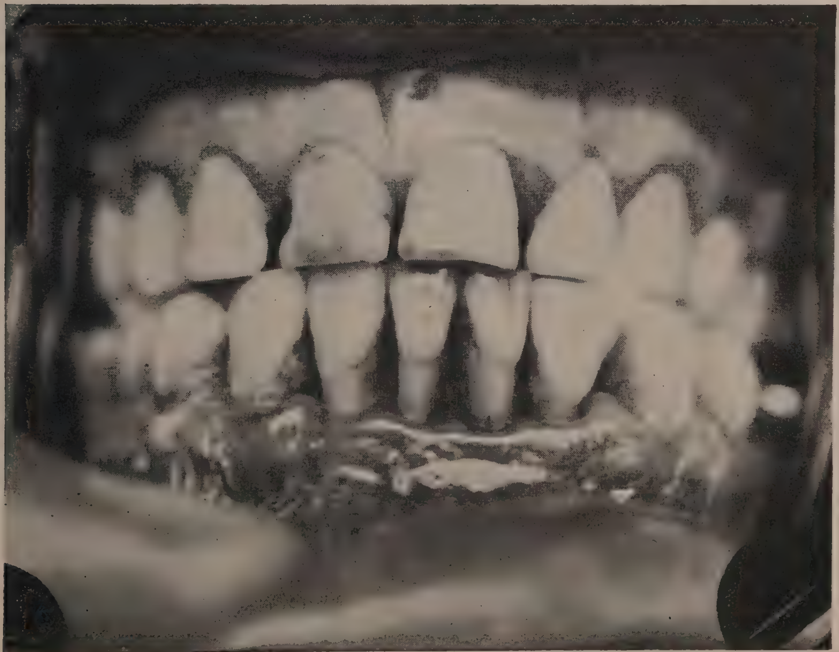

Fig. 221.—Case 201. After treatment.

will find his task hard and absorbing with the prognosis not always favorable, particularly with multirooted teeth. With single-rooted teeth and the full cooperation of the patient, the prognosis is most favorable.

Medicaments indicated at different stages of the treatment are anesthetics, anodynes, disinfectants, caustics, and tissue-building stimulants.

The mechanical procedures are complete scaling of all denuded root surfaces by the dentist, and a thorough massage of the gums with the fingers daily, in conjunction with the intelligent use of the toothbrush.

Summary

The foregoing pictures of periodontoclasia are of a group of cases covering most of the methods advocated.

Generally speaking, in all cases we use a caustic once to destroy the linings of all pockets. Next, we use stimulants only, both mechanical and medicinal. We have no use for the electric or hot cautery.

We use surgery and the packs on the market for deep pockets back of the six anterior teeth. These have been discarded anteriorly due to permanent disfigurement.

All loose single-rooted teeth are splinted with ligatures or cast splints. Reasonably deep pockets are assisted in bone and gum restorations by filling frequently with a blood clot. In the latter part of the treatment the patient is instructed in gum massage with the fingers, to be continued for the balance of his life.

CHAPTER XXXVI

ENDODONTIA*

Problem.—Several years ago, one of the most serious health problems was shifted squarely to the shoulders of the dental profession. Because of this we have changed our prospective.

Formerly we practiced dentistry to save teeth only. Now our objective is the health of our patients, and we attack their tooth problems with greater care and, we hope, more knowledge and greater success.

Correct Diagnosis.—The successful issue of such services as we may attempt for our patients is based fundamentally on a correct diagnosis, without which all is lost. This involves a full working knowledge of the physiologic and functional health of the organs or the tissues that we invade, that we may detect deviation from the normal.

Ability to Diagnose.—The ability to detect perverted function and tissue pathology is in direct proportion to the knowledge of physiology possessed by the diagnostician. The ability to classify these lesions and to give a dependable prognosis is in proportion to his knowledge of pathology.

Pain.—Local comfort and efficiency of treated teeth alone are not sufficient evidence of the success of a pulp canal operation. The general health of a patient must improve or remain good.

Pain, when present, is used as a means of differentiation in the stage of disease where vital pulps or periapical tissues are involved, but the presence or absence cannot be relied upon to indicate the amount of infection where a putrescent root canal is under consideration.

A comprehensive diagnosis requires the assistance of the radiograph. The local clinical examination should include transillumination, electrical tests, thermal changes, percussion, and the percussion note. There should be secured as complete a history as possible of the case from the time of the first dental operation to date. The objective symptoms should be noted. None of the foregoing will determine the presence of infection. Such examination can determine the probability of infection only.

As to the Radiograph.—Most of the discussion of the day deals with what we should see or perhaps what the practitioner thinks he sees in x-rays of the case.

It might be the cause of some good reflection if we take the negative side of the case and mention what we fail to see. The radiograph does not reveal the presence or absence of infection in any tissue of the body. It discloses only present density or rarefication of calcified tissues, and congestion or anemia of organic tissue, which we may compare with the normal of that tissue.

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*The term Endodontia was placed before the profession by the newly organized society of that name and covers all surgery and therapeutics employed in the protection or removal of the inside of the tooth, commonly called the pulp.

The author first heard the suggestion for the use of the word from Dr. Harry B. Johnston of Atlanta, Ga.

By deductions we conclude that deviation from normal is caused by present infection or that of some previous invasion. The usual single view of a tooth root depicts nothing about either the buccal or lingual sides of the root, and as a tooth has four sides, one-half of each tooth is not usually investigated radiographically.

Many physicians and dentists see plainly much pathology about a tooth, that is, if they see dentistry in the pulp canal. Hide the dentistry and they are at sea. Most roots are tapering, small at the apex, and longer than they appear in a radiograph. A filled foramen looks like a white dot just beyond the end of the root, and what appears as a blur beyond the root apex is many times hypercementosis.

Transillumination reveals excess hemoglobin as found in congested areas which may or may not be infected. In the absence of trauma, however, disease in soft tissues is generally the result of infection.

Electrical tests and thermal changes disclose the presence of vital pulp tissue which may or may not be infected.

Percussion or the percussion note may disclose an abnormal or congested pericementum which may or may not be infected.

The extent of osseous or cemental absorption does not express the extent of the infection. The granulated tissue filling rarefied areas may be sterile. Those of long standing generally are sterile.

Dental infection, in one person, may cause very little or no absorption, while in another it may cause condensation. The character and extent of these expressions are governed by the resistance on the part of the patient.

The quality and extent of absorption is not a measure of the danger. Some patients show large areas indicating a high degree of resistance.

Teeth without visible absorption of bone are frequently infected in the pulp, dentine, or apical tissues, whereas periapical absorption can be and has been produced by trauma or irritating medication, or even the process of permanent repair.

Dental infection involving pulp canals and root apices and the supporting structures practically always contains streptococci, of which biologically there are many types.

''**The diplostreptococcus** is present in infected teeth in more than 99 per cent of the cases, and is the germ responsible for 90 per cent of the heart involvements and produces many of the rheumatic group lesions as well as many organic functional disorders.''

The Objective Symptoms.—''Pus may be flowing from the alveolus through a sinus, and said pus be sterile. The comfortable tooth may be culturing and discharging into the blood stream the most dangerous toxins.

''**An investigation** should be made to determine the susceptibility of a patient either acquired or inherited. Each dentist should have charts for recording the information.

''**Patients should be classified** into three groups: Those with an inherited susceptibility, those with an acquired susceptibility, and those without a susceptibility, to rheumatic group lesions.

"Persons are comparable only with those within the same group.

"Individuals with a marked susceptibility to periodontoclasia have as a group a decreased susceptibility to the rheumatic group lesions." (Weston A. Price.)

A further diagnosis requires a physical examination to include the blood pictures, blood chemistry, and a bacteriologic investigation of the tooth and adjacent structures, in some borderline cases comparing this with bacteriologic findings of other parts of the body.

Few physicians and fewer dentists are fitted for this work, either in preparation or equipment.

We must here have the assistance of a laboratory specialist in chart findings and speed the day when all dentists can understand and correlate facts thus shown.

With such an examination before us, we should be able to advise the patient with safety, provided we give consideration to the following facts as developed by research.

Tooth Root Anatomy.—In the management of pulpless teeth and the teeth that must be rendered pulpless, it is of utmost importance that full consideration be given to the anatomy of the roots of the teeth and of the apical third of these roots in particular.

A very large percentage of pulps end at more than one foramen. It is not uncommon to find several foramina with some going to exit quite some distance crownwise from the root apex. These facts are illustrated by the following microphotographs with legends. (Figs. 222 to 264 inclusive.)

Of the various teeth in the mouth, by far the largest percentage of multiple canals is found in the roots of the molar teeth. As to the age of the patient, the greatest number of multiple canals may be found in case the teeth are extracted and sectioned when the patient is between the ages of 20 and 45 years.

Before the roots of a tooth are fully matured, or at the time of normal eruption and before the tooth comes into full occlusion, there is generally but one foramen, as shown in Fig. 263, with the pulp extending flush with the end of the root. Cases are found, however, where lateral canals have been established before root development has been completed, as shown in Fig. 264. As a rule, there are several arteries with the accompanying veins and nerves passing to the pulp by way of this opening. When the tooth comes into occlusion or articulation, the building of cementum and dentine in the apical region is much accelerated. The cementum is built around each group resulting in multiple canals to as many foramina.

Diseased areas are in part due to the practice of pulp devitalization through the use of destructive agents (notably AS_2O_3), thereby leaving in the inaccessible canals dead tissue always adjacent and probably attached to the vital tissue. The result is obvious.

With these fully accepted facts before us, it is rather remarkable that we should see and hear at this time articles and lectures on "How to treat and fill the foramen [singular]." These are no longer interesting or instructive as they

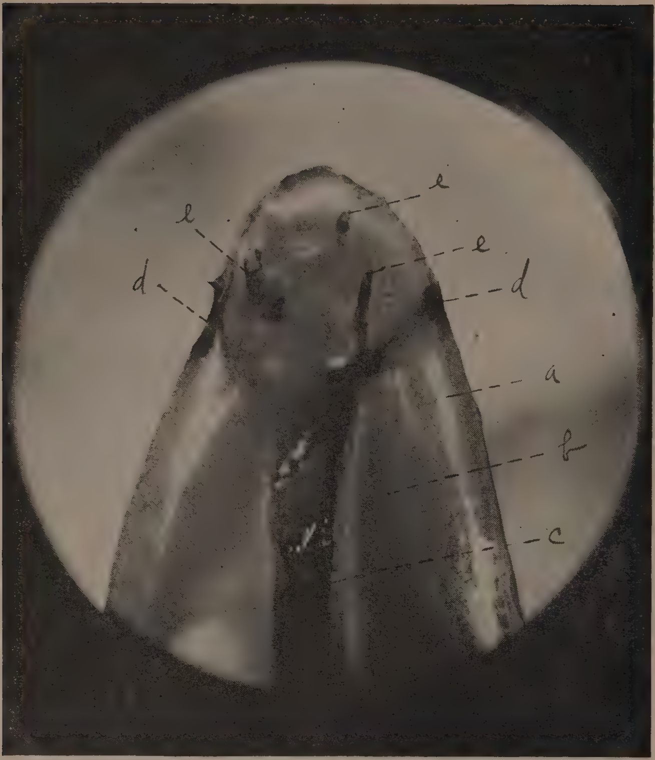

Fig. 222.—Upper left cuspid. *a.* Cementum. *b.* Dentine. *c.* Pulp. *d d d d d d.* Lateral branches. (Magnification ×25.)

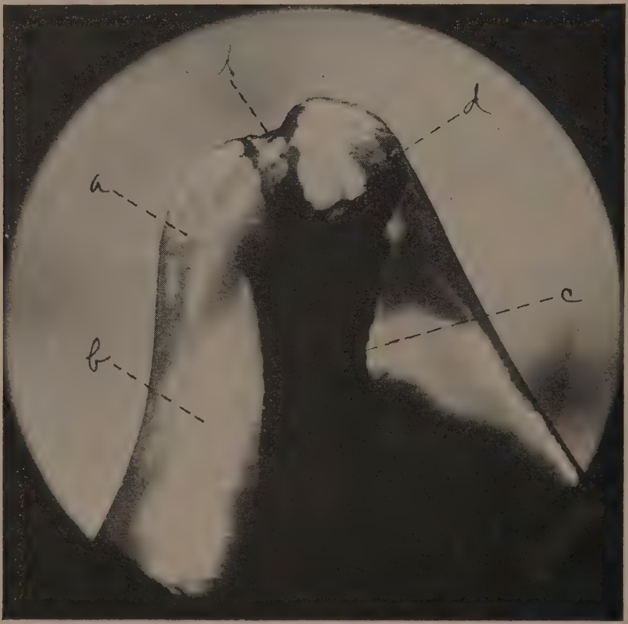

Fig. 223.—First left lower molar distal root. *a.* Cementum. *b.* Dentine. *c.* Pulp. *d d.* Foramina. (Magnification ×25.)

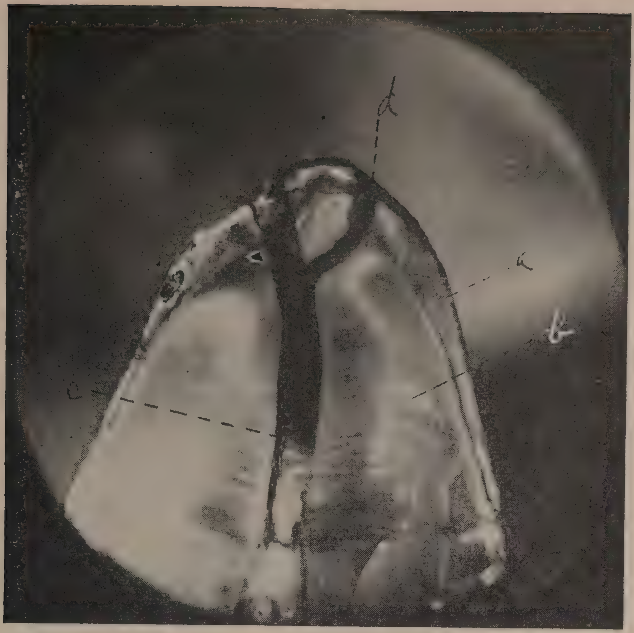

Fig. 224.—Left lower lateral incisor. *a*. Cementum. *b*. Dentine. *c*. Pulp. *d d*. Foramina. (Magnification ×25.)

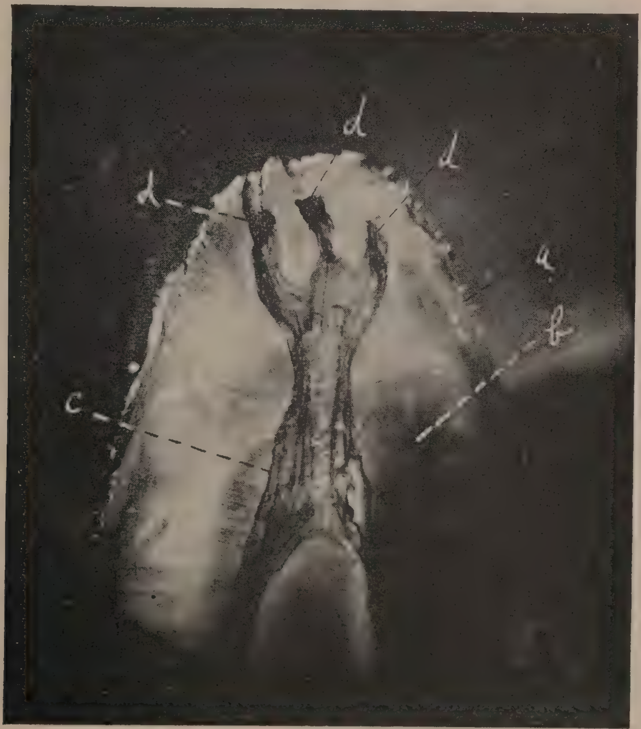

Fig. 225.—Right lower central incisor. *a*. Cementum. *b*. Dentine. *c*. Pulp. *d d d*. Lateral branches. (Magnification ×25.)

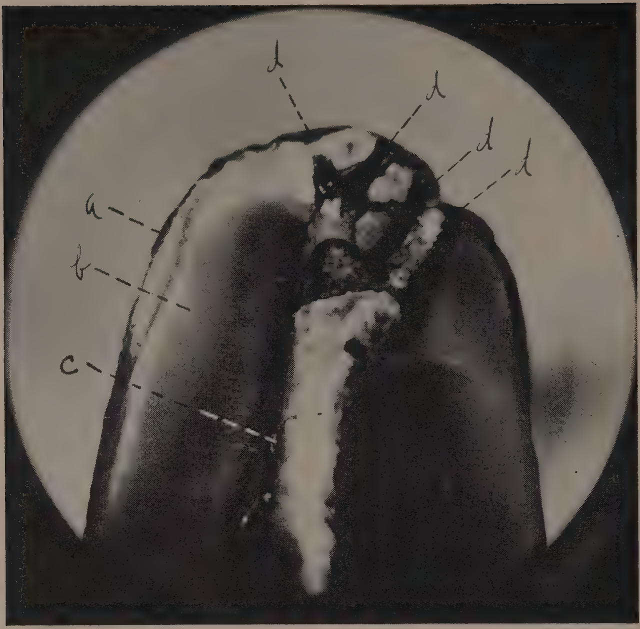

Fig. 226.—First left upper molar, mesiobuccal root. *a.* Cementum. *b.* Dentine. *c.* Pulp. *d d d.* Lateral branches. (Magnification ×25.)

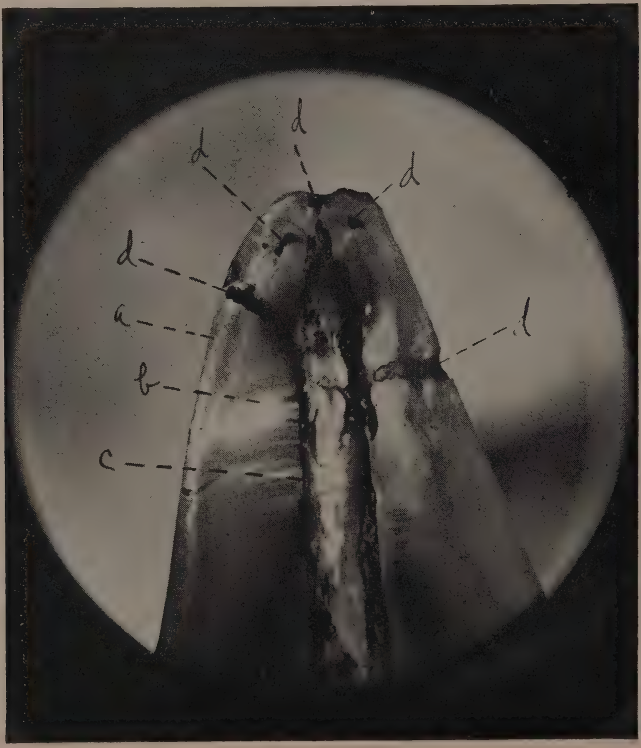

Fig. 227. Second right superior bicuspid. *a.* Cementum. *b.* Dentine. *c.* Pulp. *d d d d d.* Lateral branches and foramina. (Magnification ×25.)

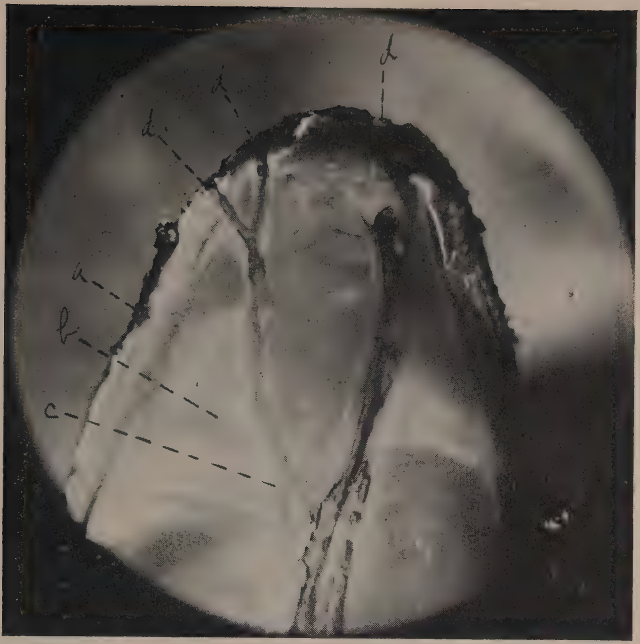

Fig. 228.—Second left lower bicuspid. *a.* Cementum. *b.* Dentine. *c.* Pulp. *d d d.* Lateral branches and foramina. (Magnification ×25.)

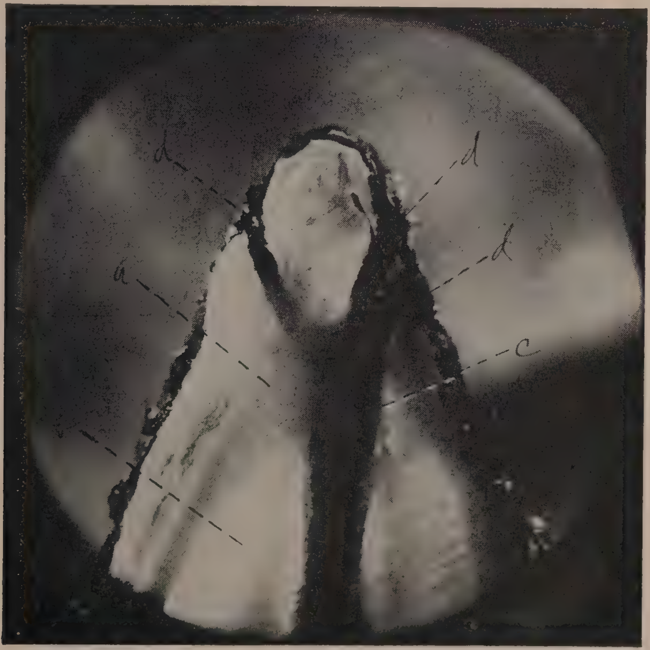

Fig. 229.—Right superior cuspid. *a.* Cementum. *b.* Dentine. *c.* Pulp. *d d d.* Foramina. (Magnification ×25.)

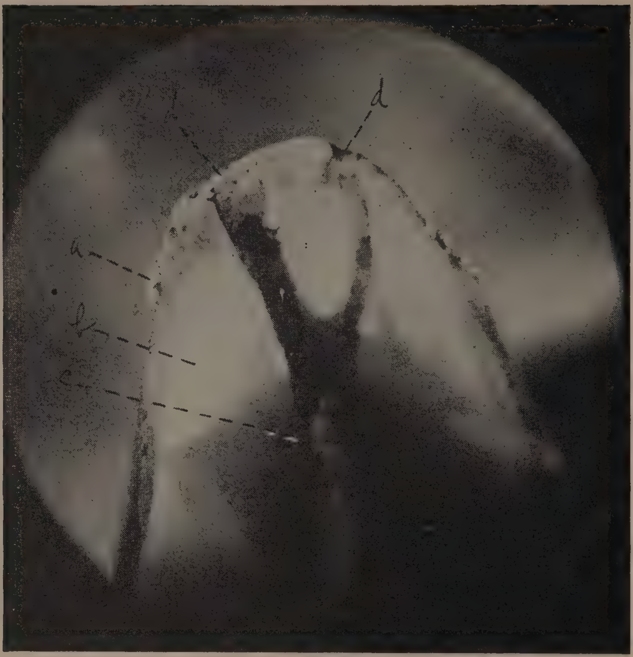

Fig. 230.—Right inferior lateral incisor. *a.* Cementum. *b.* Dentine. *c.* Pulp. *d d.* Foramina. *e.* Communicating canal. *f.* Lateral branch. (Magnification ×25.)

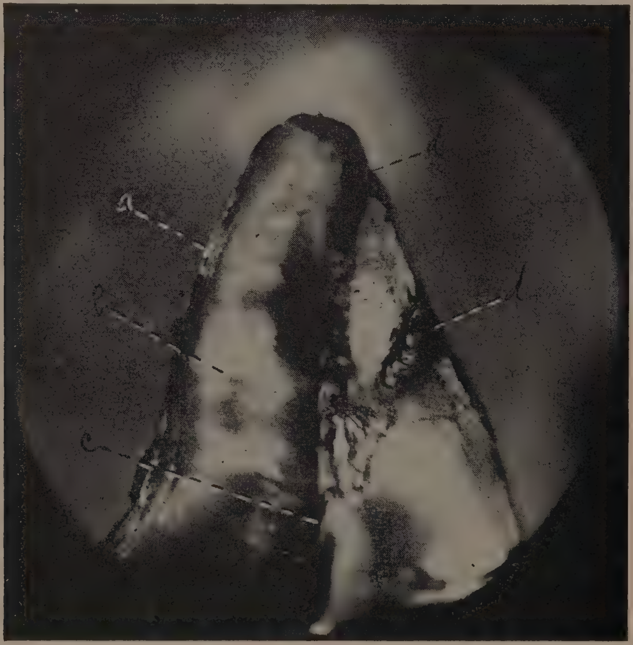

Fig. 231.—Left superior central incisor. *a.* Cementum. *b.* Dentine. *c.* Pulp. *d d.* Foramina. (Magnification ×25.)

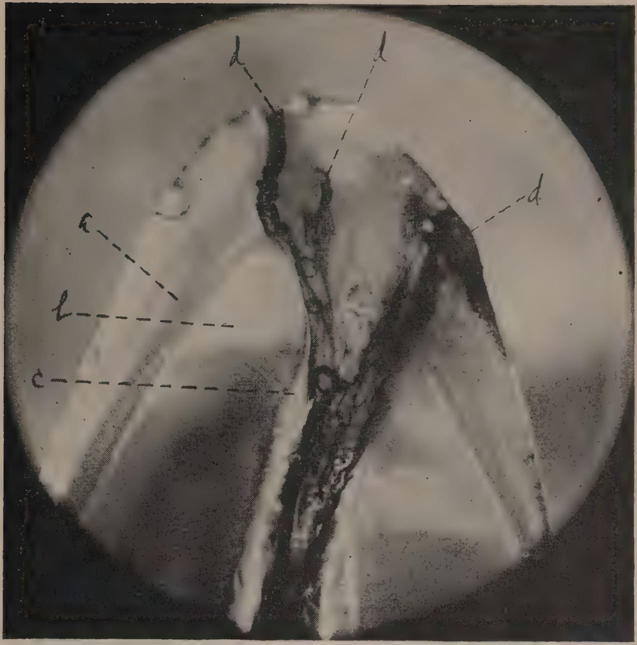

Fig. 232.—Right inferior cuspid. *a.* Cementum. *b.* Dentine. *c.* Pulp. *d d.* Foramina. *e.* Lateral branch. (Magnification ×25.)

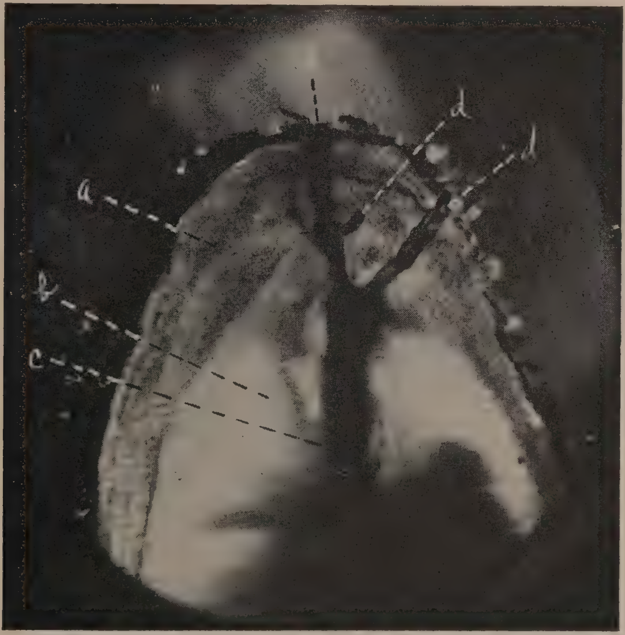

Fig. 233.—Second left superior bicuspid. *a.* Cementum. *b.* Dentine. *c.* Pulp. *d d.* Foramina. (Magnification ×25.)

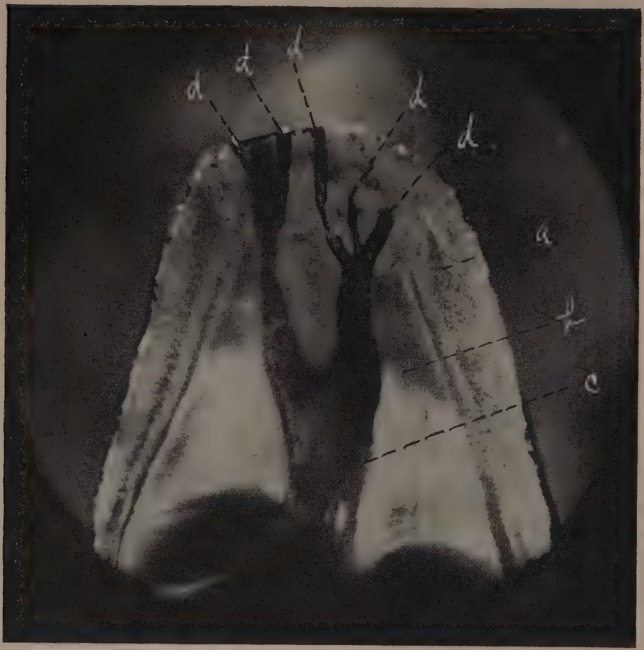

Fig. 234.—Second right superior bicuspid. *a.* Cementum. *b.* Dentine. *c.* Pulp. *d d d d d.* Lateral branches. (Magnification ×25.)

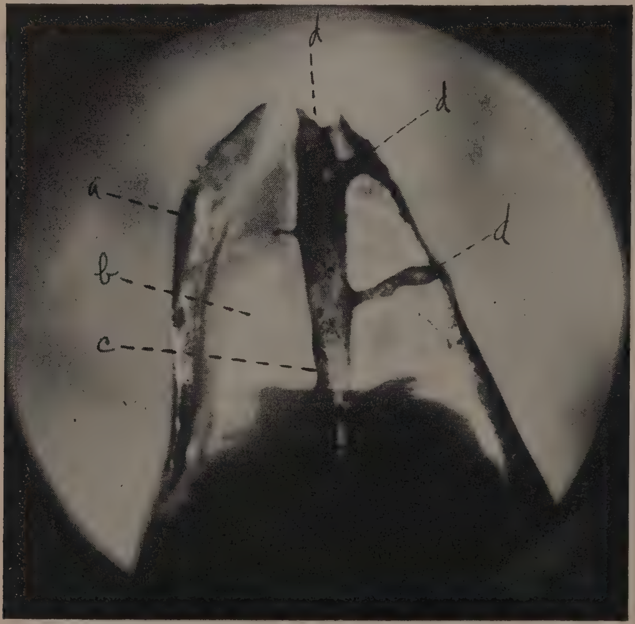

Fig. 235.—Left superior lateral incisor. *a.* Cementum. *b.* Dentine. *c.* Pulp. *d d d.* Foramina. (Magnification ×25.)

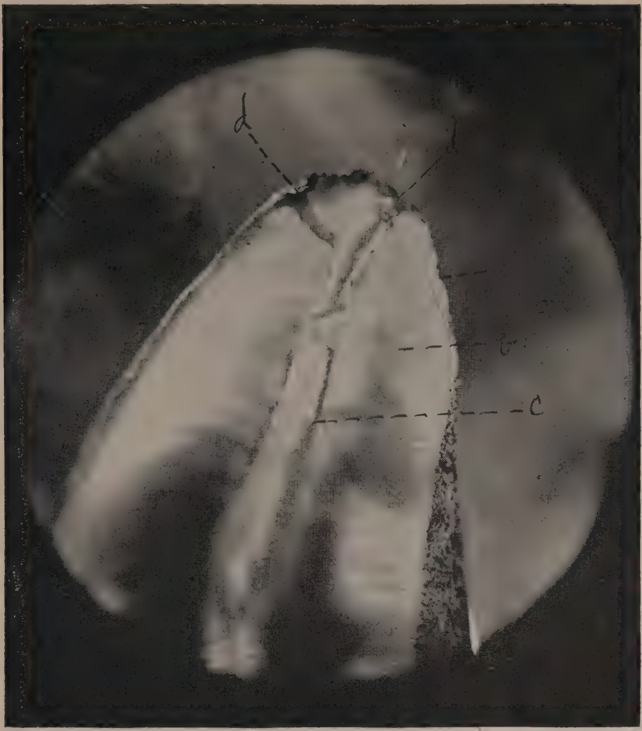

Fig. 236.—Left inferior central incisor. *a.* Cementum. *b.* Dentine. *c.* Pulp. *d d.* Foramina. (Magnification ×25.)

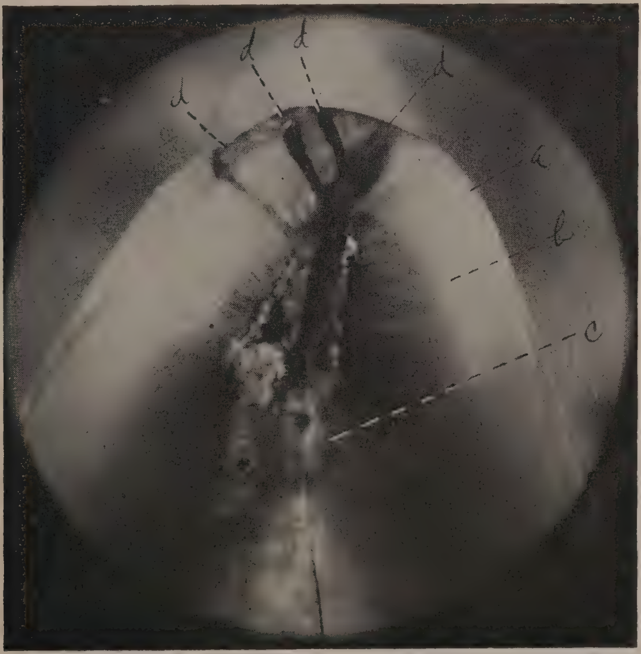

Fig. 237.—Second right inferior molar distal root. *a.* Cementum. *b.* Dentine. *c.* Pulp. *d d d d.* Foramina. (Magnification ×25.)

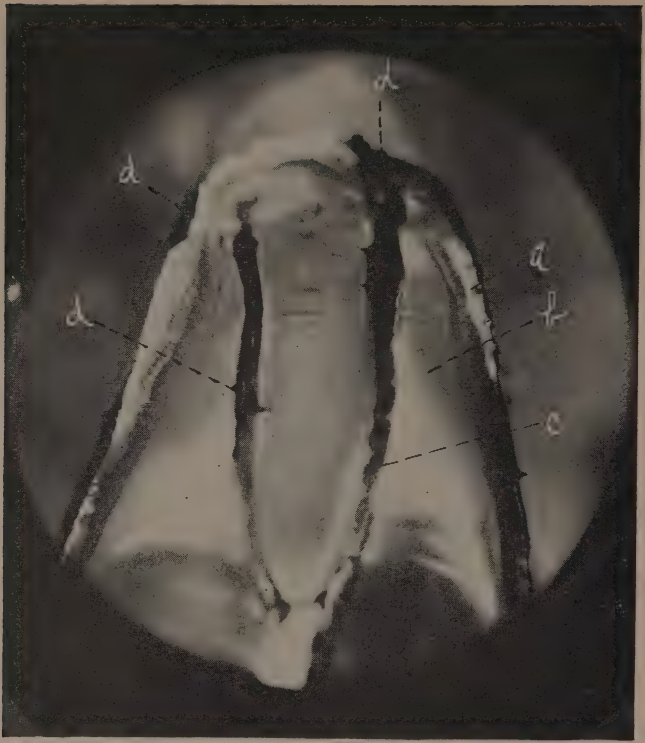

Fig. 238.—Second left inferior bicuspid. *a.* Cementum. *b.* Dentine. *c.* Pulp. *d.* Foramen. *e.* Lateral branch. (Magnification ×25.)

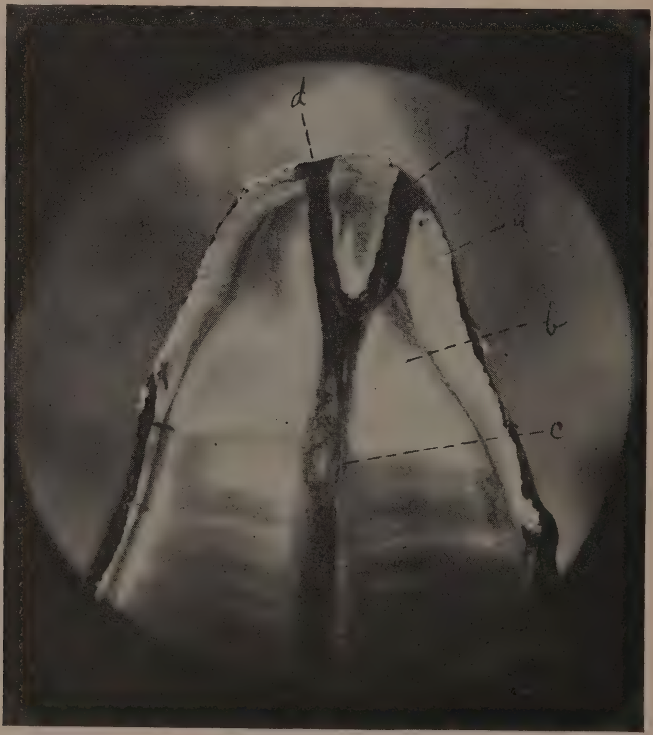

Fig. 239.—Right superior cuspid. *a.* Cementum. *b.* Dentine. *c.* Pulp. *d d.* Foramina. (Magnification ×25.)

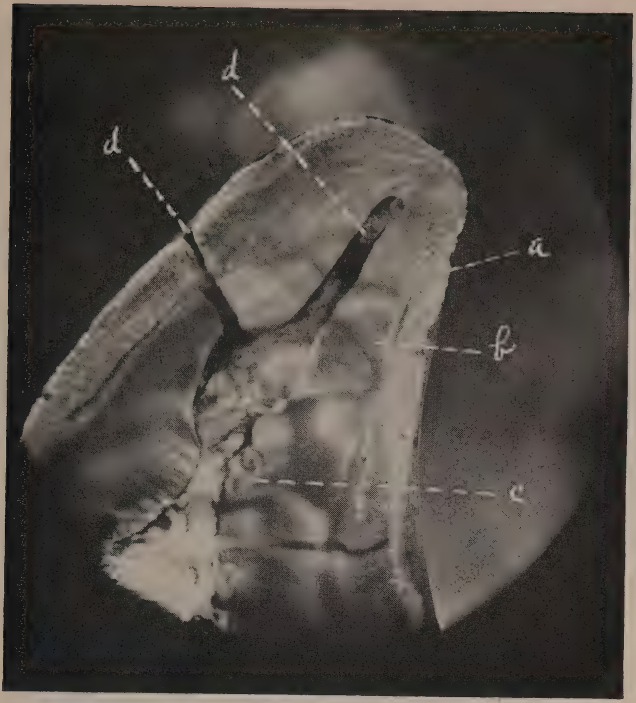

Fig. 240.—Right inferior cuspid. *a.* Cementum. *b.* Dentine. *c.* Pulp. *d d d.* Lateral branches. (Magnification ×25.)

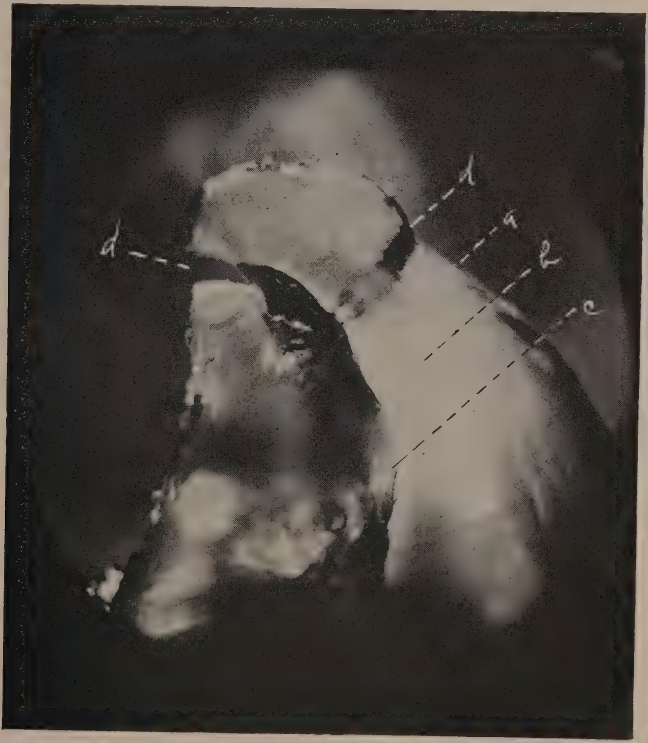

Fig. 241.—Second left superior bicuspid. *a.* Cementum. *b.* Dentine. *c.* Pulp. *d d.* Foramina. (Magnification ×25.)

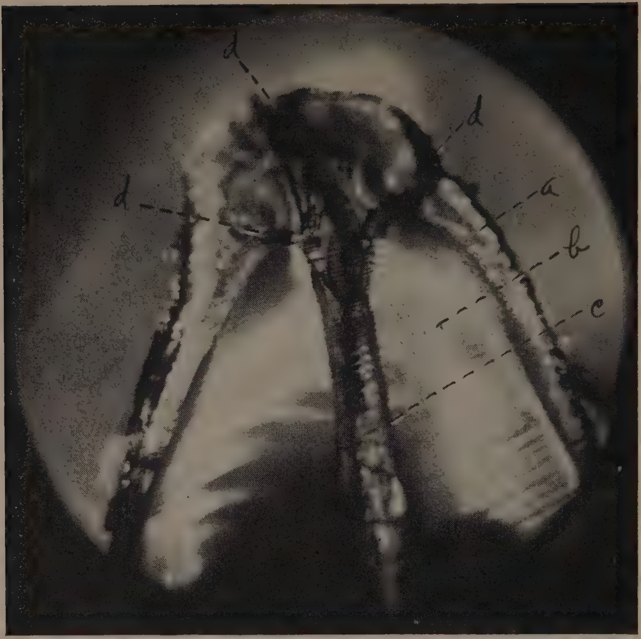

Fig. 242.—Left superior cuspid. *a.* Cementum. *b.* Dentine. *c.* Pulp. *d d.* Foramina. (Magnification ×25.)

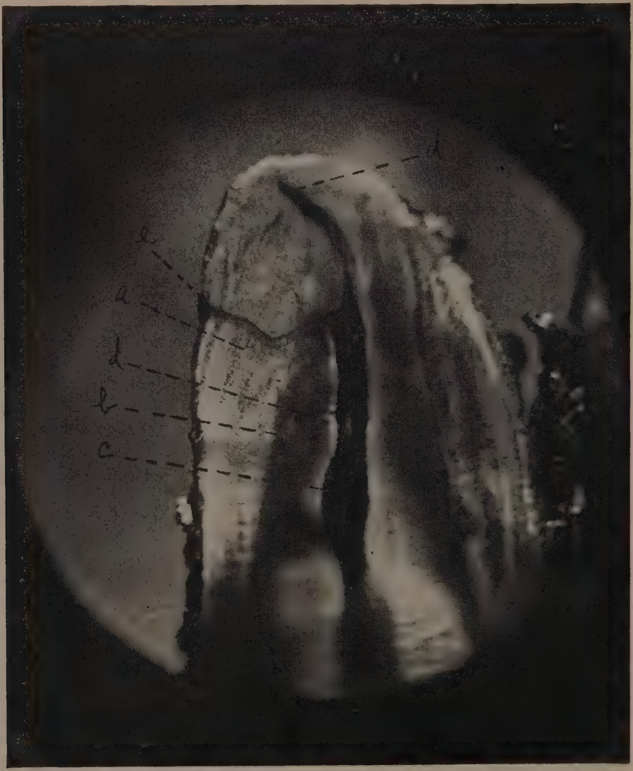

Fig. 243.—First left superior bicuspid, lingual root. *a.* Cementum. *b.* Dentine. *c.* Pulp. *d d.* Lateral branches. (Magnification ×25.)

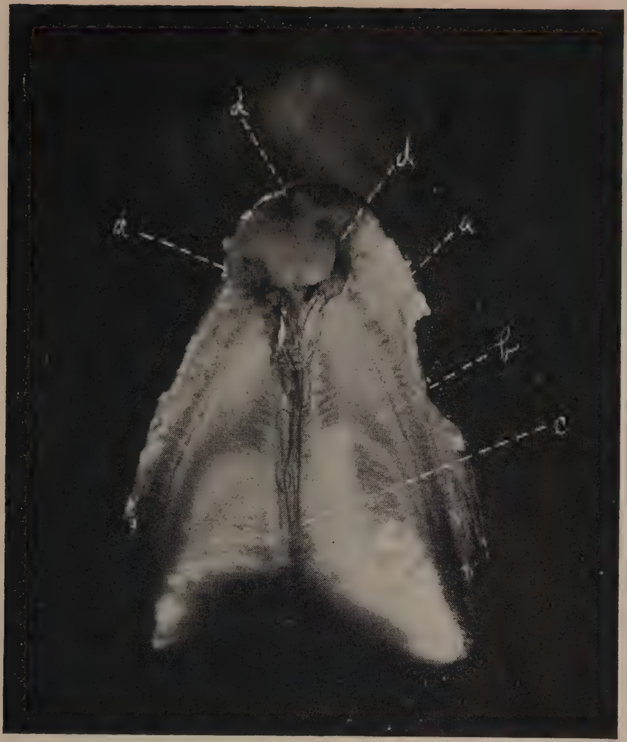

Fig. 244.—First right inferior bicuspid. *a.* Cementum. *b.* Dentine. *c.* Pulp. *d d d.* Lateral branches. (Magnification ×25.)

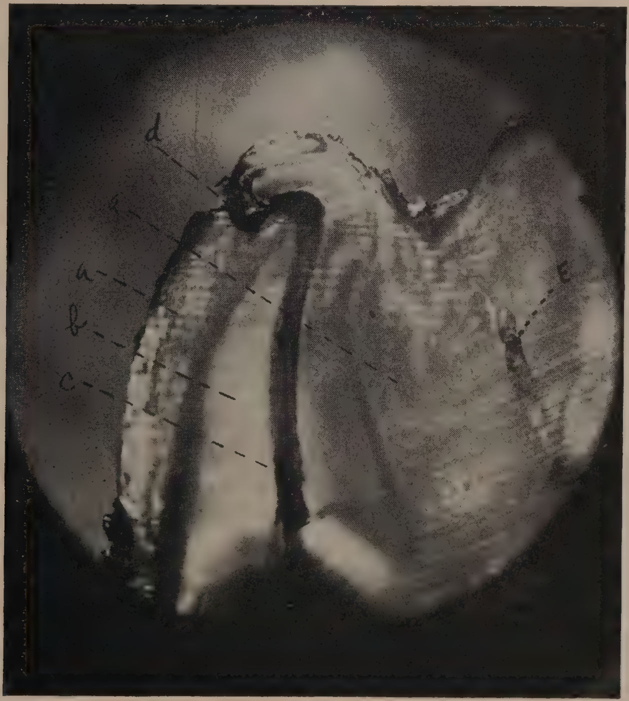

Fig. 245.—First right superior bicuspid, buccal root. *a.* Cementum. *b.* Dentine. *c.* Pulp. *d d.* Foramina. *e.* Pulp branch. (Magnification ×25.)

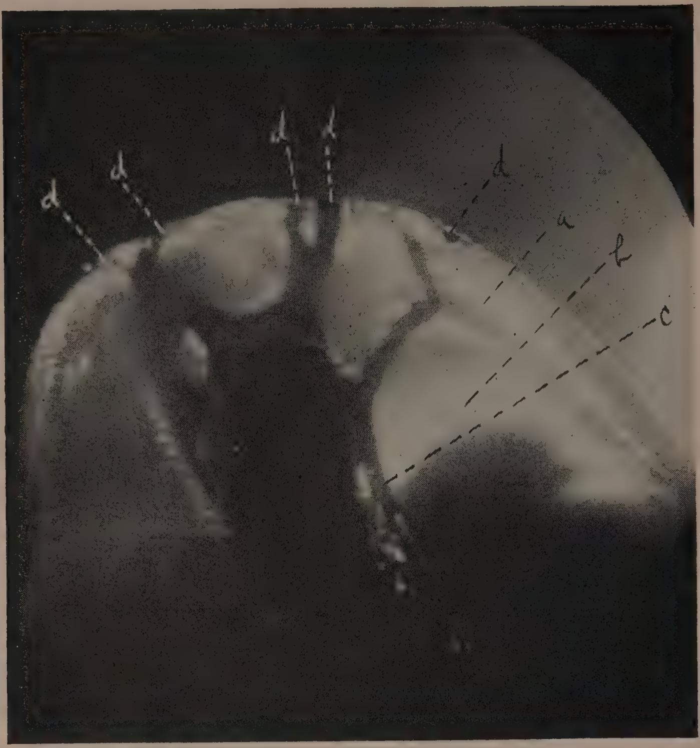

Fig. 246.—Second upper right bicuspid. *a.* Cementum. *b.* Dentine. *c.* Pulp. *d d d d d.* Foramina. (Magnification ×25.)

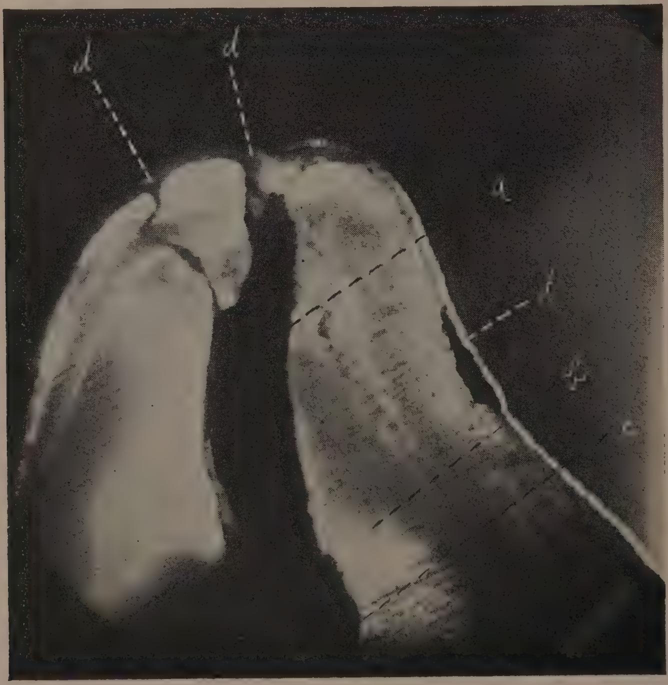

Fig. 247.—Left lower cuspid. *a.* Cementum. *b.* Dentine. *c.* Pulp. *d d d.* Foramina. (Magnification ×25.)

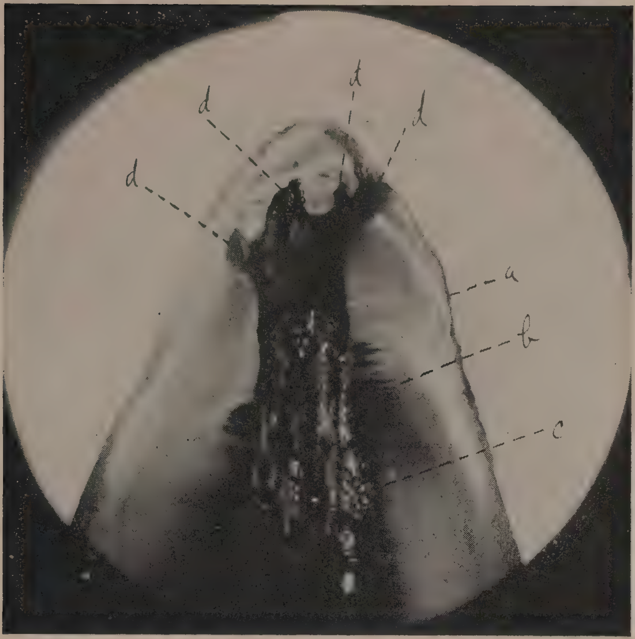

Fig. 248.—First left lower molar, distal root. *a.* Cementum. *b.* Dentine. *c.* Pulp. *d d d d.* Lateral branches. (Magnification ×25.)

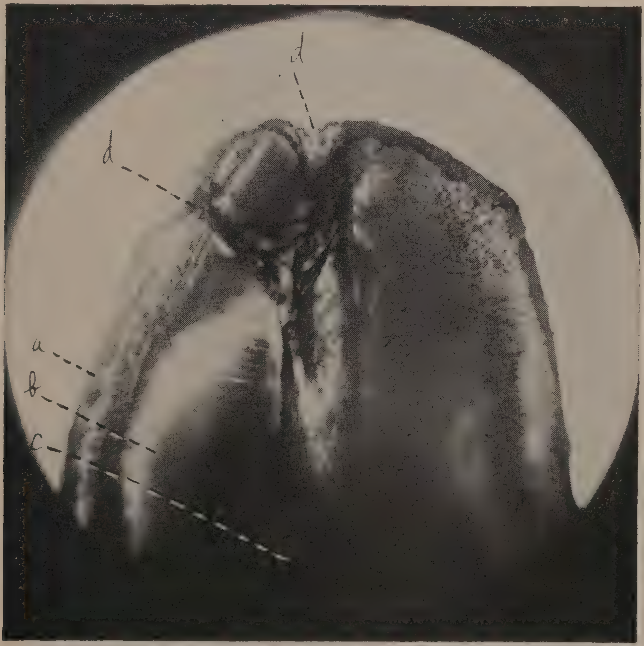

Fig. 249.—First right superior molar, lingual root. *a.* Cementum. *b.* Dentine. *c.* Pulp. *d d.* Foramina. (Magnification ×25.)

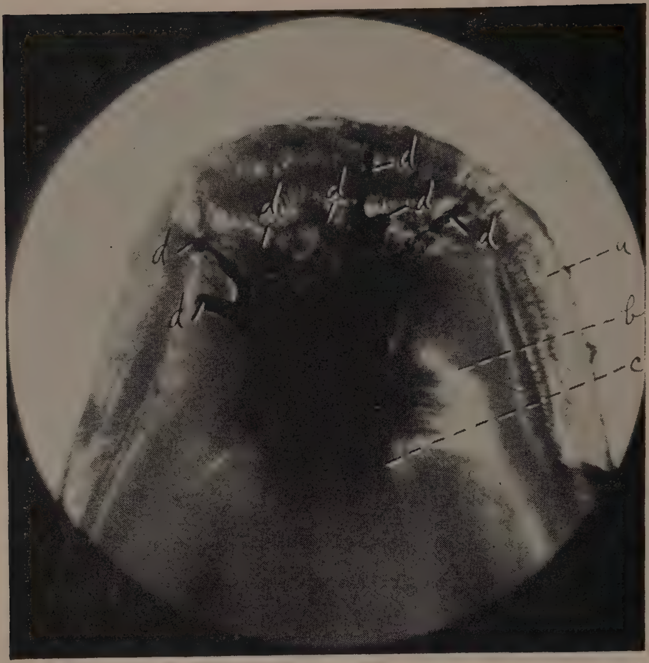

Fig. 250.—First right inferior molar, distal root. *a.* Cementum. *b.* Dentine. *c.* Pulp. *d d d d d d.* Lateral branches. (Magnification ×25.)

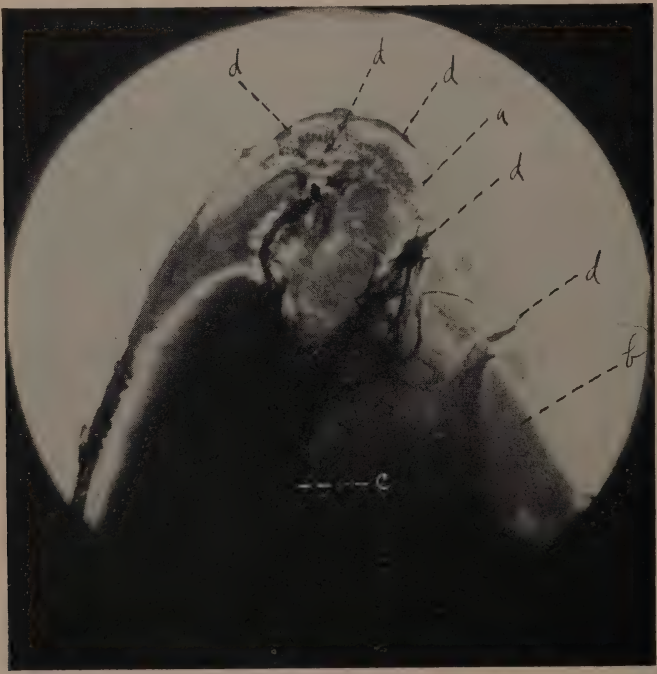

Fig. 251.—First right superior molar, mesial buccal root. *a.* Cementum. *b.* Dentine. *c.* Pulp. *d d d.* Foramina. *e e.* Lateral branches. (Magnification ×25.)

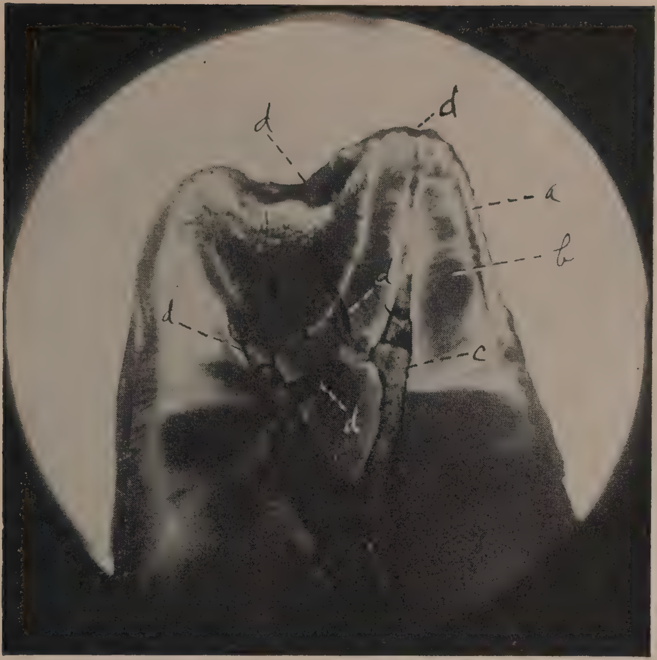

Fig. 252.—Second left inferior molar, distal root. *a.* Cementum. *b.* Dentine.. *c.* Pulp. *d d d.* Lateral branches. (Magnification ×25.)

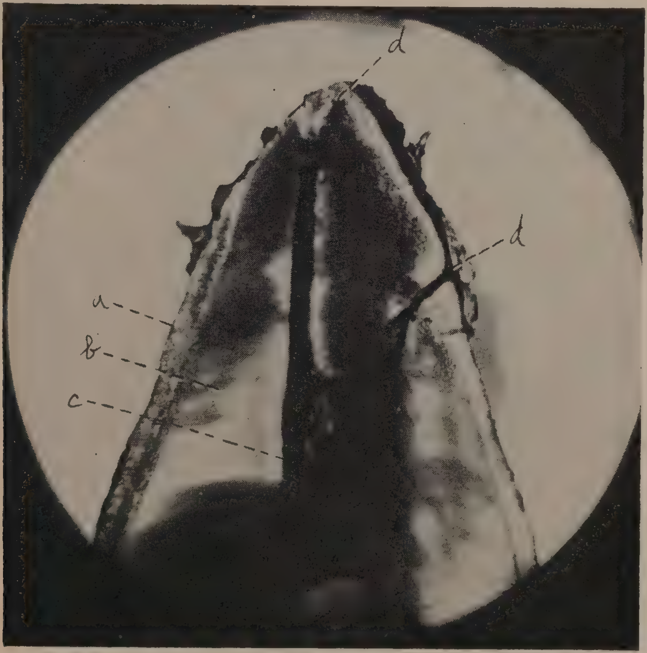

Fig. 253.—First left superior molar, distal buccal root. *a.* Cementum. *b.* Dentine. *c.* Pulp. *d d.* Lateral branches. (Magnification ×25.)

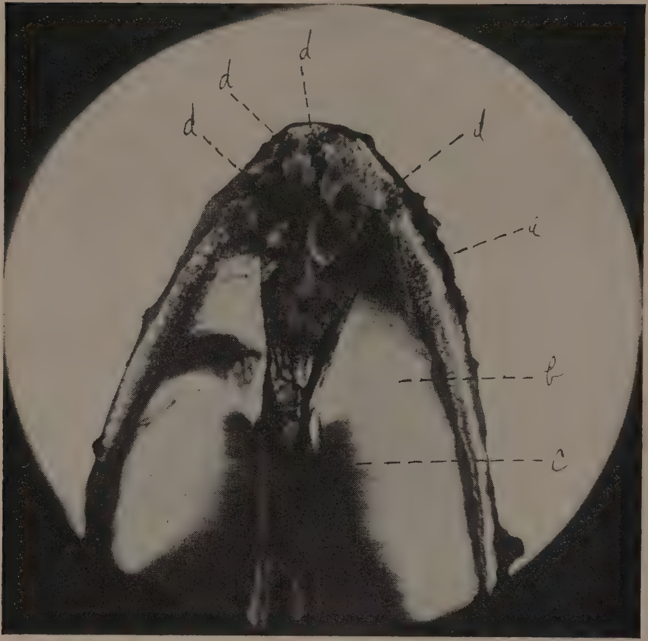

Fig. 254.—Second right superior bicuspid. *a.* Cementum. *b.* Dentine. *c.* Pulp. *d d d.* Lateral branches. (Magnification ×25.)

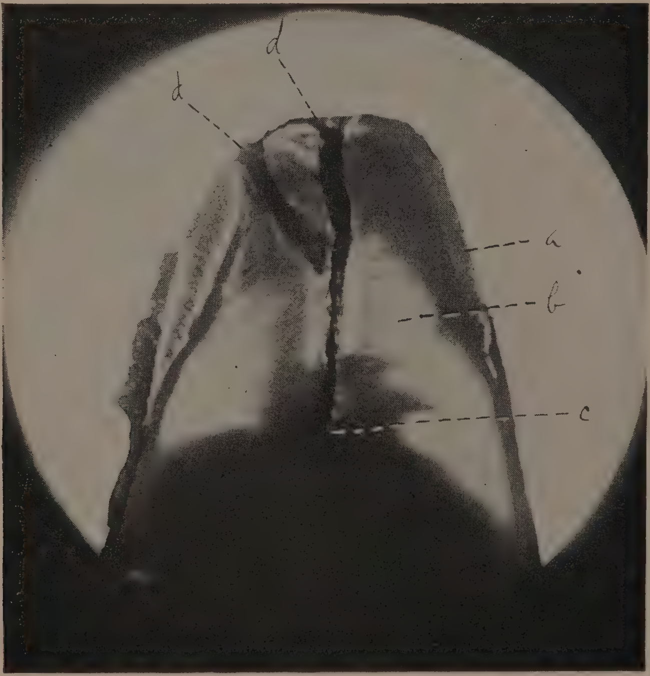

Fig. 255.—First left inferior bicuspid. *a.* Cementum. *b.* Dentine. *c.* Pulp. *d d.* Foramina (Magnification ×25.)

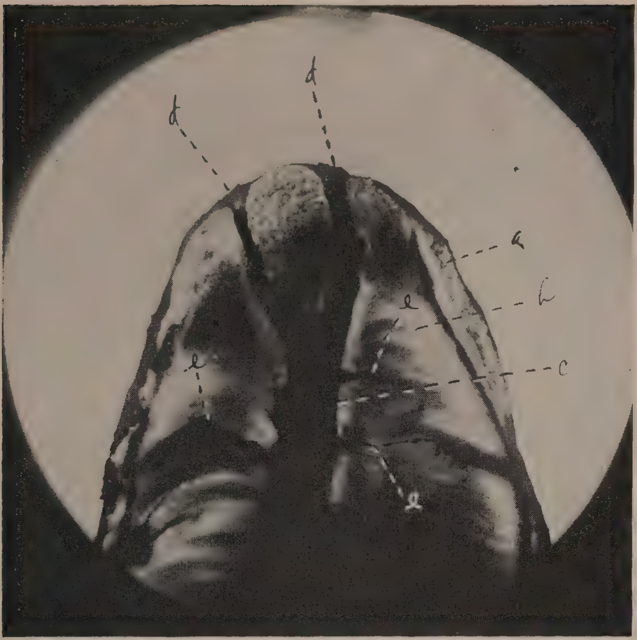

Fig. 256.—Second right superior bicuspid. *a.* Cementum. *b.* Dentine. *c.* Pulp. *d d d.* Foramina. *e e e.* Lateral branches. (Magnification ×25.)

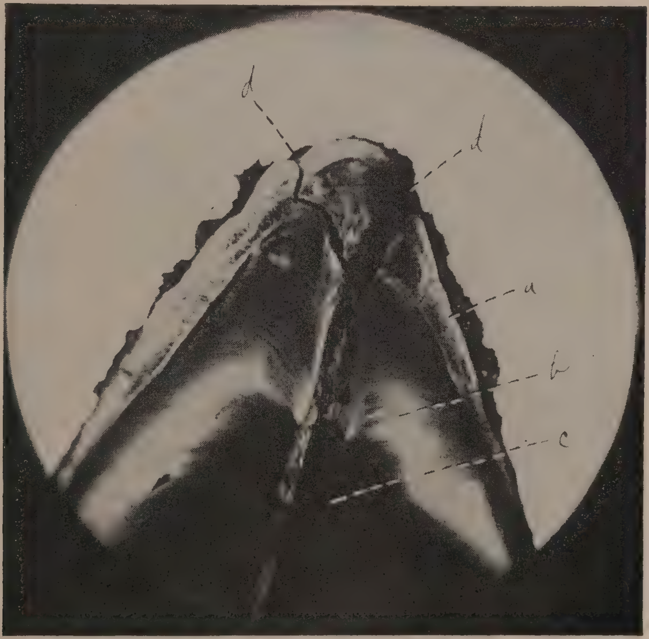

Fig. 257.—Right superior cuspid. *a.* Cementum. *b.* Dentine. *c.* Pulp. *d d.* Foramina. (Magnification ×25.)

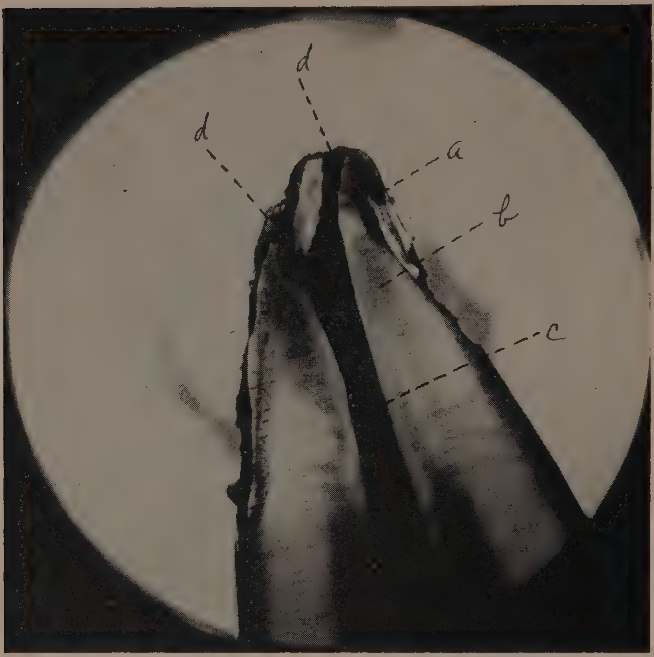

Fig. 258.—Right inferior cuspid. *a.* Cementum. *b.* Dentine. *c.* Pulp. *d d.* Foramina. (Magnification ×25.)

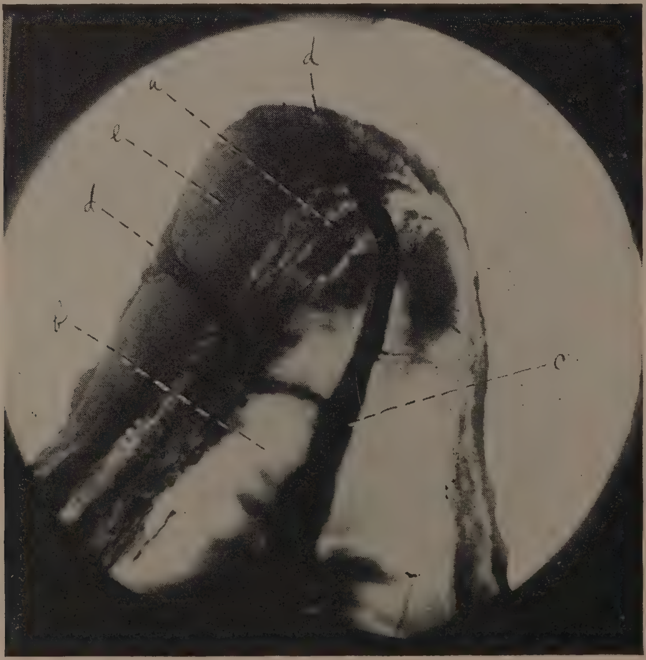

Fig. 259.—Right superior cuspid. *a.* Cementum. *b.* Dentine. *c.* Pulp *d d.* Foramin. (Magnification ×25.)

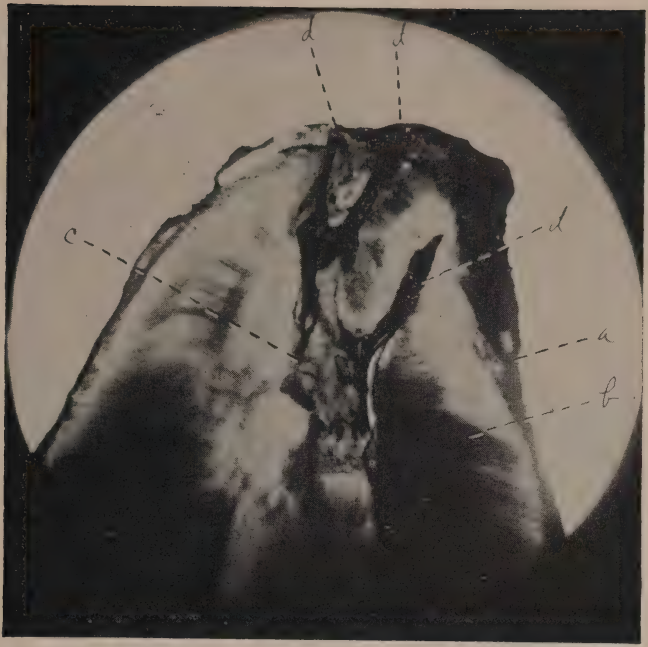

Fig. 260.—Left inferior lateral incisor. *a.* Cementum. *b.* Dentine. *c.* Pulp. *d d d.* Lateral branches (Magnification ×25.)

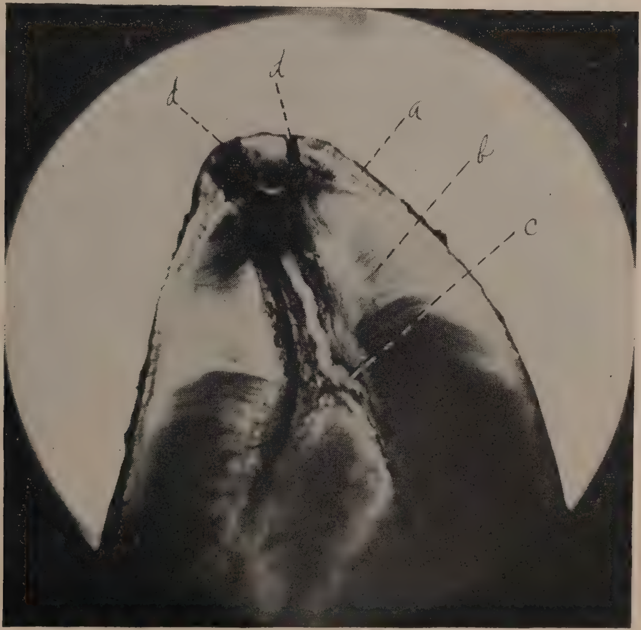

Fig. 261.—Right inferior central incisor. *a.* Cementum. *b.* Dentine. *c.* Pulp. *d d.* Foramina. (Magnification ×25.)

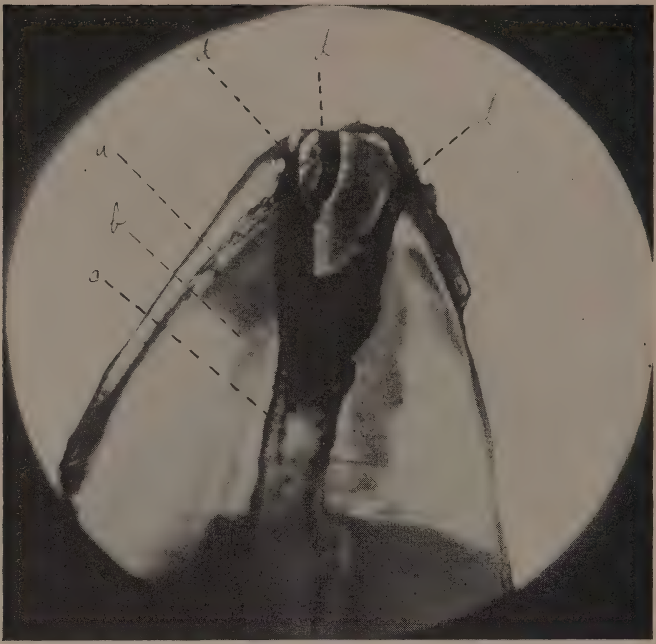

Fig. 262.—Right inferior central incisor. *a.* Cementum. *b.* Dentine. *c.* Pulp. *d d d.* Foramina. (Magnification ×25.)

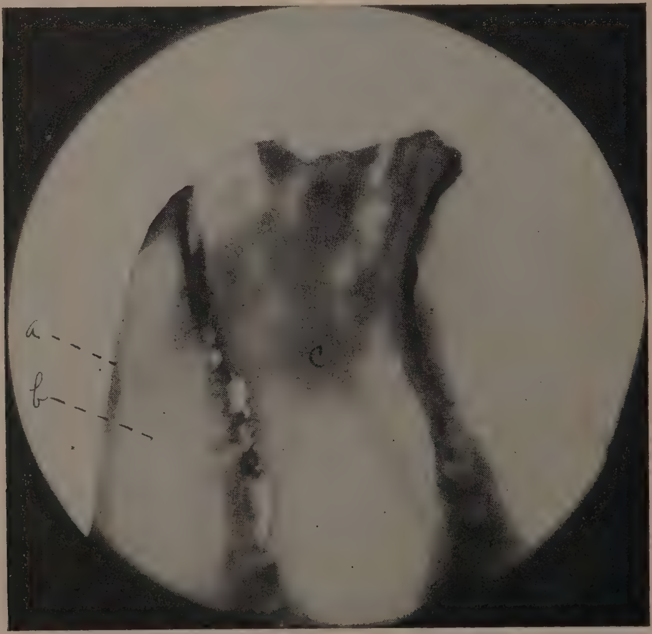

Fig. 263.—Second right inferior molar. Tooth was extracted soon after eruption. *a.* Cementum. *b.* Dentine. *c.* Vacant pulp canal. (Magnification ×25.)

do not deal with the question which is really before us. "How to manage the canals and the foramina [plural]" is the mooted question and is far from settled at this time.

The anatomy of the apical third of the roots of teeth is such that pulpectomy is impossible in the majority of cases and has not yet been practiced, to say nothing of filling the multiple canals and foramina if perchance some dentists should accidentally remove an entire pulp to each of its several foramina. A few of the writers in their recent articles have made statements that the "entire pulp tissue must be removed if we are to hope for success," and yet they fail to give us a technic by means of which we may hope to mechanically remove the contents of these canals.

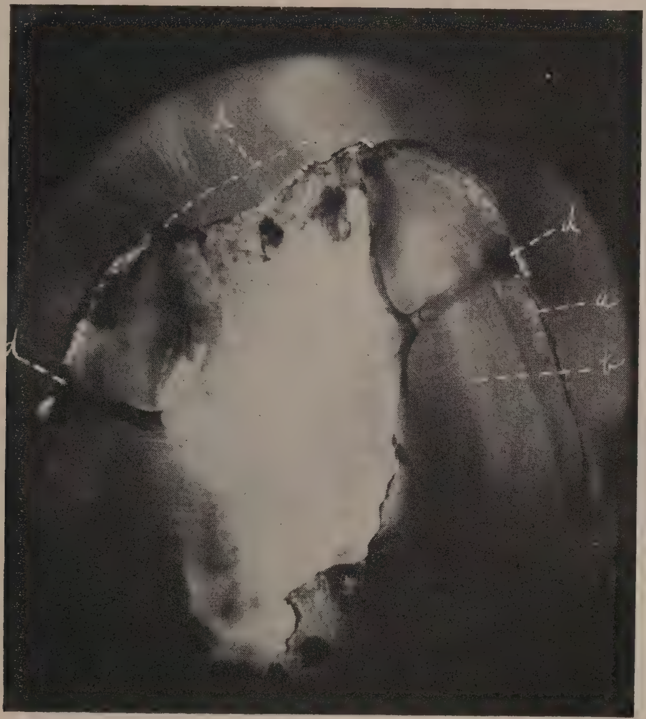

Fig. 264.—Second left superior bicuspid. *a.* Cementum. *b.* Dentine. *c.* Vacant pulp canal. *d d.* Foramina of lateral canals. *e.* Main foramen. This tooth was extracted soon after it had erupted to make room in orthodontic work. Although the end of the root is far from completely formed, there had already been established two well-developed lateral branches to the pulp.

The author has finally been forced to abandon the idea that anyone is able at this time to remove all of the pulp tissue from other than a very small percentage of the roots of teeth. This percentage is so small that it is not worthy of consideration. For that reason all pulp operations must be attempted with the supposition that the case in hand has more than one canal to more than one foramen. If teeth cannot be saved without leaving part of the pulp tissue in situ, the extraction of nearly every tooth wherein there is an exposed pulp is the ultimate end.

When the pulp has been devitalized as with arsenic, we at once have before us the problem of one, two, three, four, or more lateral branches, mostly in the apical region filled with dead pulp tissue which is impossible of removal. Some are shutting their eyes to the facts, and are leaving this dead tissue in position. Others are attempting to preserve this tissue in situ with some form of preservative, which harks back to Egyptian dentistry. The great number of diseased areas about the apices of the teeth is the answer. However, when a local anesthetic is used and a part of the pulp is removed (which is all that is possible) under aseptic precautions, the lateral branches are left vital and we have a case of partial pulpectomy.

In so far as the lateral branches are concerned, the dentist may do this operation either intentionally or from necessity. The writer prefers to consider the operation as intentional. If we are forced to rely on this disposition of the pulp in the lateral branches, and we are successful, there can be no argument against the addition of the accessible one to the number. The fact that one foramen is in direct line with the main canal does not change the pathology.

Again, if the extirpation of the pulp entirely to one foramen results in cutting off several lateral branches, we then have as many separate wounds; whereas, if the pulp is amputated short of the position where branching generally begins, we shall have but one wound thereby lessening the likelihood of failure in the operation. In radiographing many pulpless teeth, it appeared that the majority of those teeth which did not give evidence of diseased areas had canal fillings which had not been placed to the end of a pulp canal and which did not reach any one of the foramina. In fact, some of these pulps had been amputated at the floor of the pulp chamber.

Investigation soon disclosed the fact that these cases had a common history; that the pulp had not been devitalized; that the attempted pulpectomy had been done with the use of an anesthetic: nerve block, pressure anesthesia, or a general anesthetic. Those of long standing gave radiographic indications of canal obliteration as well as much restricted periapical spaces. Figs. 222 to 264 inclusive illustrate different classes of cases with conditions noted. A microscopic examination of very thinly ground cross sections of the roots of these teeth disclosed the fact that in the majority (approximately 90 per cent) of such teeth, the unremoved portion of the pulp was still vital, but that the lumen of the canals had been materially lessened by the construction of an osteoid tissue.

The remainder, perhaps 10 per cent, of such teeth showed that all canals had been completely obliterated to where the pulp tissue meets the periodontal membrane which dips into and fills the foramina. When several of these complete closures had been noted following partial pulp removal and partial root filling (unintentional), it was decided to bring the matter to the attention of the profession.

The other members of the dental faculty in the University of Nebraska were called to the dark room, and the results of the work thrown on the screen in February, 1920. In May, 1920, a series of lantern slides was exhibited to the members of the Nebraska State Dental Society. Following these public demonstrations, a paper as a preliminary report was written exclusively for and published by *The Dental Cosmos,* volume 62, page 767, June, 1920.

Fig. 271 was published at that time, and is from a photomicrograph of a cross section of the root of a second lower bicuspid at the junction of the apical and middle thirds. A search of dental literature revealed the fact that others had noted the obliteration of pulp canals by the formation of an osteoid tissue, but none seem to have associated this tissue metaplasia with partial pulp removal, intentional or unintentional.

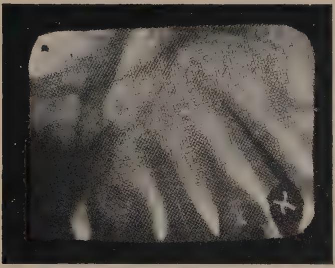

Fig. 265.

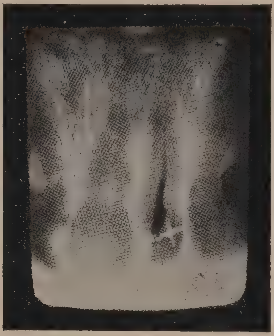

Fig. 266.

Fig. 265.—Radiograph taken after partial root fillings in teeth marked *x* had been in place eight years in the bicuspid and ten years in the cuspid. The partial filling of the roots was accidental. Pulps were removed with cocaine pressure anesthesia.

Fig. 266.—The radiograph of this case was taken some years after an accidental partial root filling. The root filling consisted of Callahan varnish and gutta-percha.

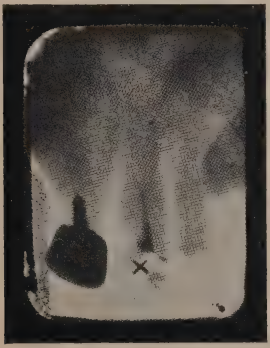

Fig. 267.

Fig. 268.

Fig. 267.—Patient stated this root filling had been in position many years. The root filling was not removed, but chlora-percha with gutta-percha point was the popular filling at the time this partial root filling was made.

Fig. 268.—Patient stated these three teeth marked *x* had been filled at different times over a period of about ten years. From her description, the dentist used pressure anesthesia.

Dr. I. D. Branch, in 1851 (*Dental Cosmos* **4**: 214), reported the case of a tooth broken off by the kick of a horse, and that the end was closed up with "osseous matter."

Dr. Charles Tomes, the same year (*A System of Surgery,* second edition, page 469), reported a case of pulp canal closure in the remaining portion of root following the breaking off of the root in an attempted extraction.

Dr. Harry S. Chase, in 1868 (*Dental Cosmos,* volume 10, page 17), goes to some extent into the pathology of what he terms "ossification of the pulp." He states, "When a pulp has thus been transformed, it is neither dentine nor cementum, neither is it bone. It is only calcified connective tissue."

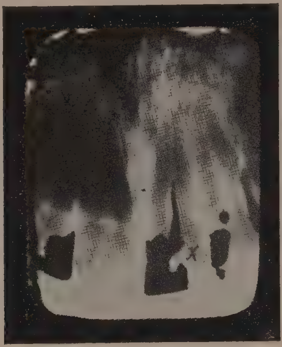

Fig. 269.

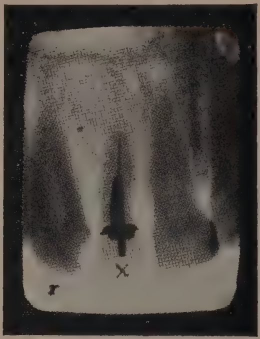

Fig. 270.

Fig. 269.—The root filling in tooth marked *x* had been in position less than two years. It is quite evident that the calcification of the pulp had not taken place, and there is slight indication of a rarefied condition about the apex of this tooth.

Fig. 270.—The pulp of this tooth marked *x* was removed with cocaine pressure anesthesia ten years previous to making this radiograph. Condition seemed to be perfect. The root canal filling comes just short of the root end. If there are any lateral branches, they are not shown.

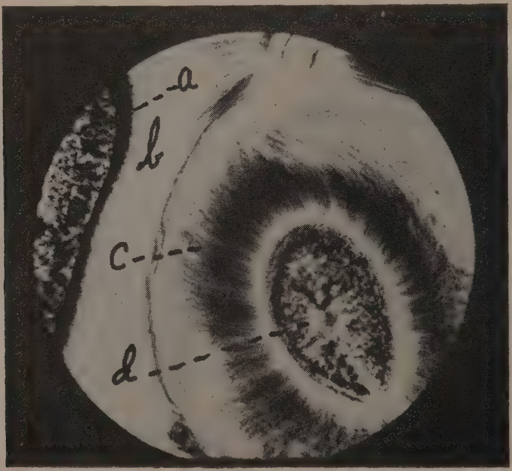

Fig. 271.—Case 107. Section "C." Cross section of lower bicuspid six years after partial pulpectomy. First published by the writer in the *Dental Cosmos* of June, 1920, and later in the *Dental Items of Interest,* February, 1923. *a.* Cementum. *b.* Dentine. *c.* Adventitious dentine. *d.* Osteoid tissue. (Magnification ×40.)

Dr. S. J. Salter, in 1874 (*Dental Pathology and Surgery,* page 71), classifies this as an osteoid tissue and says, "It may contain true bone lacunae, especially resembling those of the crusta-petrosa." This was his only reference to this being cemental tissue.

Mr. D. E. Caush, in 1893 (*Report of The World's Columbian Dental Congress,* volume 1, page 14), published some excellent photomicrographs of this structure, and seems to associate the building of this new tissue only with inflammatory processes of the subdental tissues.

Dr. Arthur Hopewell-Smith, in his textbook (*The Histology and Patho-Histology of the Teeth and Associated Parts,* first edition, page 474) published in 1893, describes this change in pulp tissue and gives ''injuries to the dental pulp'' as its cause. While he does not express himself as to the possibility of this particular tissue metaplasia, resulting from partial pulpectomy, intentional or accidental, he does state that ''it is due to the traumatization of the dental pulp.''

In the study of this pulp repair by means of tissue metaplasia in the pathological laboratory of the University of Nebraska, special consideration was given to the conditions and influences under which this osteoid tissue replaced the pulp tissue. A full report of the investigation has already been published in the *Dental Summary* beginning with the April, 1921, issue, and extending through the issues of June, July, August, and September, reporting the work of the two years previous. A more extended treatise on the subject will be found in the 1923 *Dental Items of Interest.*

In the October, 1921, number of the *Dental Cosmos* there is an article by Dr. Carl J. Grove, wherein he publishes a photomicrograph showing this same structure completely closing the main canal. Dr. Grove's text reads ''foramen.'' We think this is in error, as the osteoid tissue is surrounded first by adventitious dentine and just outside of this is normal dentine, showing that this portion of the canal was at one time filled with pulp tissue. It is very probable that additional sections of this same root would have shown a completely closed canal crownwise to the point of pulp excision.

Vital Tooth Defined.—It is generally accepted that bone is vital when there is attached a vital functioning periosteum. That is our conception of a vital tooth. Hence we propose this definition: ''A vital tooth is a tooth the cementum of which is attached to its alveolus by a living functioning periodontium.''

In case this attachment is lost, the tooth is a dead tooth and is exfoliated like any other sequestrum. Should a portion of the root become detached and yet housed by vital tissue (as when the root apex becomes denuded), there exists an attached sequestrum, as with other bony structures, and it is the best of surgery to remove such denuded portion, allowing the vital attached portion to remain in situ, the operation of apicoectomy. (See Chapter XLVII.)

The presence or absence of the enamel or pulp is not a determining factor as to the vitality of a tooth. The writer is not alone in this conception of the pulp canal problem, as many of our distinguished editors, authors, and teachers took this stand years ago, and accumulating evidence continues to prove the soundness of the position from both physiologic and pathologic premises.

We hope that we will not be misunderstood as we do not want our readers to infer that we have been opposed to the general removal of millions of teeth from the mouths of people who have been made ill by the saturation of their teeth with arsenic and other poisonous drugs, leaving behind decomposing tissue for bacterial growth and by the actual planting of bacteria beyond the foramina.

We assisted to the extent of our opportunities in these extractions. That time has largely passed, however, particularly with skilled operators who really care to render the best service.

Pulp canal operations must be done with care and intelligence, and above all in a surgically clean manner.

If a pulp is in danger of death, it had best be excised surgically while anesthetized (pulpectomy) to as near the accessible foramen as possible. Do not lacerate the part or parts of the pulp if any must remain. The operation is then termed partial pulpectomy. (See Chapter XXXIX.)

Selection of Patients.—When contemplating pulp and pulp canal operations, the patient's health must be given due consideration. Any pulpotomy results in only a small wound in a field of restricted circulation, particularly for adult patients; hence there is a greater risk in diabetic, tubercular, anemic, and syphilitic conditions.

Bone repair must be relied upon if we are to bring health back to the structures about the apices of infected teeth and to the location of an apicoectomy.

All debilitating diseases and dyscrasias, as general infections, perversions, faulty assimilation and elimination, particularly in old age, retard or inhibit bone repair.

This has the effect of slowing down the results of treatment and the repair following our surgical procedures, all of which should be reckoned with in such cases.

Selection of Teeth.—All contemplated cases should be x-rayed before acceptance. We thereby determine much of the anatomy of the tooth and surrounding structures, particularly as to abnormalities about the teeth, generally spoken of as pathology. In dealing with vital pulp cases we include all teeth, as under proper procedure the lateral branch so frequently met with may be relied upon to be closed with osteoid tissue.

In putrescent pulp cases, however, we prefer to accept only those which may be easily operated on for apicoectomy as this may be necessary in any case subsequent to root canal filling. This, then, pretty well eliminates the molar teeth when putrescent. The writer accepts molars with caution and reservation.

Fees.—With patients forced to rigid economy there is no possibility in private practice of saving the teeth which have a pulp involvement necessitating a canal operation.

The number of sittings in canal cases will vary from two to ten and even more. The number of x-rays for the series in such cases run from ten to twenty.

The operative hours at the chair will vary from two hours, as for a pulp amputation and canal filling, to as many as twenty hours or even more in complicated putrescent cases. All this is entirely independent of any tooth restoration to be done. The fees will therefore be of consequence and must vary with each operator, depending on what his time might otherwise bring him. Such cases may generally be handled for a fee slightly less than that for a double inlay bridge replacing the extracted tooth in question.

Classification.—The management of teeth with pulp involvement and the sequelae, periodontal complications, are now attempted under improved conditions and methods of technic. It can therefore be more intelligently considered and practiced when the varied cases are separated by a rather definite classification.

The author submits the following classification in an effort to bring out distinctly the salient features necessary to success in the varied treatments and requirements of pulp canal surgery and therapy.

1. **Pulp Protection.** (See Chapter XXXVII.)
2. **Pulpectomy.** (See Chapter XXXVIII.)
3. **Partial Pulpectomy, Unavoidable.** (See Chapter XXXIX.)
   - A. Lateral branches
   - B. Canal obstruction
   - C. Crooked canals
4. **Partial Pulpectomy, Intentional.** (See Chapter XL.)
   - A. Permanent teeth of children with underdeveloped roots
   - B. Deciduous teeth
5. **Pulp Putrescence, Simple.** (See Chapter XLI.)
   - A. Open
   - B. Closed
6. **Pulp Putrescence, Complicated.** (See Chapters XLII-XLIII.)
   - A. Acute
     - Without fistula
     - With fistula
     - Deciduous teeth
   - B. Chronic
     - Without fistula
     - With fistula
     - With denuded cementum
     - Deciduous teeth
7. **Pulp Canal Filling, Mechanical.** (See Chapter XLVI.)
8. **Correcting Previous Pulp Canal Surgery.** (See Chapter XLV.)
9. **Apicoectomy.** (See Chapter XLVII.)
10. **Prognosis in Endodontia.** (See Chapter XLIX.)

CHAPTER XXXVII

PROTECTION OF THE VITAL PULP

The normal pulp has no tactile sense, neither is it responsive to thermal changes even though they vary considerably from the body temperature.

When robbed of its normal covering and protection the reverse of the above conditions quickly develops. The sense of touch becomes very acute and any contact with foreign substances causes great pain. This is best illustrated when a tooth is broken through its crown by a blow, thus exposing the pulp. At first the pulp may be touched with the finger or an instrument without the knowledge of the patient but in a very few minutes the same will cause unbearable pain. Also, at first the cold air does not affect the pulp, but, coincident with the development of the tactile sense, comes a repugnance to the cold.

The chief idiosyncrasy of the pulp is its response to thermal changes and especially to cold, when these changes are rapid or the pulp is in any way hyperemic. A normal pulp will tolerate without response quite a range of temperature when the change is brought about slowly. This is generally the case when the pulp is covered with the full crown of the tooth. But when, through decay or other causes, this covering is all or partially lost, the changes are so rapid that the peculiar responsive features spoken of are developed.

The recuperative powers of the pulp have been discussed by many writers. The previous teachings have been that the recuperative powers of this little organ were very limited. Recent research, however, has developed the fact that the possibility of repair in pulp tissue is much in harmony with the repair of the medullary tissue, or bone marrow. Pulp tissue responds readily to the repair of aseptic wounds in that tissue.

It would seem that those who have believed and taught these theories have based their opinions on the great mortality of pulps, following exposure or traumatic injury, but have not taken into consideration the importance of aseptic measures in dealing with the exposure of this delicate tissue to infection. You should and may expect the same results here as elsewhere in dealing with vital tissue.

The protection of the pulp from its greatest enemy, sudden thermal changes, is most essential, and as most of our desirable filling materials are good conductors of heat, it becomes necessary to place some substance which is a poor conductor between the filling and the dentine, this operation being termed ‘‘capping the pulp.’’

The indications for pulp protection are not always clear, but will involve a consideration of the age of the patient, the extent of loss of dentine, the location of the cavity in the tooth, the location in the mouth, the length of time the pulp has been exposed, the stage of hyperemia, the general health of the patient, and the possibilities of pulp infection.

The age of the patient has a bearing on the successful issue of a conservative treatment, as the teeth of the young are more easily saved from further irritation through capping than are the teeth of those past middle age, while at the same time they demand capping more frequently under the same conditions. Again, the pulp should be saved if possible until the teeth are fully formed, and many times the teeth of the younger patients are badly decayed and the pulp in great danger before the teeth are complete; hence, if the pulp can be conserved and devitalization avoided, it is of great good to the patient.

In advanced age the apical openings become smaller and many become much contracted, barely accommodating the vessels with a normal flow of blood so that a very slight congestion may cause death from strangulation or gangrene.

When a large amount of dentine has been lost, even though the pulp as yet seems normal, it is safe practice to avoid the placing of the best conductors, such as gold or amalgam, in close proximity to the pulp, as repeated shocks to the pulp through the filling from thermal changes may bring on hyperemia of that organ. In the use of phosphate of zinc cement in such cases, there should be a suitable pulp capping to prevent the irritating effect of phosphoric acid.

The location of the cavity is a factor in the demands for pulp protection, as well as the probability of success in extreme cases. The first portions of the pulp to show hyperemic conditions are those nearest to the point of irritation. These congestions are more dangerous when they appear in the body of the pulp, as they do where decay approaches the pulp in the gingival third. Hence, when a pulp is nearly exposed in this location, it demands greater protection and is at the same time harder to save than when the horns of the pulp are involved.

The location of the tooth should be considered. Anterior teeth are subject to greater extremes of heat and cold than are the molars, hence the demand for preventive protection with the anterior teeth should be remembered. At the same time their exposed position makes pulp capping more hazardous and it should be practiced with great care in this location. Again, less risk should be taken in the capping of pulps in the anterior portion of the mouth as it is better to amputate a number of questionable pulps than to have one die in the tooth with its consequent discoloration.

The length of the time the pulp has been exposed to the irritating influences is to be taken into account, as the shorter the time of exposure, the greater the probabilities of success in capping.

The stage of hyperemia should be a safe criterion where there are actual pulp complications, as there will be in almost every deep-seated cavity. In active hyperemia, from causes other than bacteria, it is safe to protect the pulp from future irritation and insure its conservation. When the symptoms of passive hyperemia have developed, however, it is not safe practice to attempt to restore the pulp to normal and expect permanency.

The symptoms of active hyperemia when the pulp demands protection and success may be expected, are:

First, when the excavated cavity exposed to the air causes a continued pain not of a throbbing nature and the condition is relieved by packing the cavity with dry cotton.

Second, when a blast of air from the chip-blower causes a quick, sharp, shooting pain which subsides as quickly as it came.

Third, when the pulp shows the power of accommodation as evidenced by tolerating a draft of cold air when the same is gradually applied.

Fourth, when it is improbable that the pulp has become badly infected.

Pulps infected with bacteria should be excised as too large a percentage of those exposed and capped die and thereby bring reproach upon dentistry in general and chagrin to the careful operator.

The time was when the profession attempted to conserve all portions of the pulp found to be vital. This was in the days of imperfect root canal treatment and filling, however, and about as many abscesses followed one kind of treatment as the other. But at the present time the partial removal of a pulp is attended with such universal success that the capping of exposed pulps, in general, is unwarranted, as most pulps are infected at the time of exposure. Even in the case of an accidental exposure in the preparation of a cavity, neither cavity nor instruments are surgically sterile.

The general health of the patient must be considered when choosing between the conservative or radical treatment of the pulp. With the same conditions presented, the pulps in the teeth of the anemic patient, those wherein the vital processes are at low ebb or the elimination of the vital ash is imperfect and cell metabolism is deficient, protective means of conservation are more imperative, while at the same time less risk should be taken in questionable cases.

With robust and particularly plethoric patients, all inflammatory processes run a rapid and riotous course, and when the pulp has taken on any stage of hyperemia, changes toward dissolution are of rapid succession.

In deep-seated cavities it is not unlikely that the thin layer of the dentine covering the pulp is infected. The pulp should be protected from invasion by thorough disinfection of the overlying dentine, with medication, previous to filling, as well as by placing next to the dentine under the filling a permanent dressing which will exert a mild antiseptic influence for some time following the operation.

The requirements of the materials used in protective procedures are:

First, that they shall be poor conductors of thermal changes.

Second, that they shall be nonchanging in character, both as to consistency and bulk.

Third, that they have no action upon the pulp.

Fourth, that they may be introduced into deep-seated cavities without pressure.

The materials advocated for this purpose are numerous and the market is flooded with preparations of a secret nature which are warranted to save the pulp in almost any stage of dissolution, but the operator who pins his faith to such slipshod methods will sooner or later find that he has been duped, and his grief is measured by the extent to which he has employed these cure-all methods.

There are four distinct classifications wherein success may be expected in methods of pulp protection. The treatment of each class is here given.

First Class.—In the progressive stage of caries wherein but little dentine has been lost, yet a blast of air from the chip-blower causes a quick, sharp pain, passing off as soon as the draft of air is checked, we find the simplest form demanding protective measures. This is the class most often neglected by the operator and many times irreparable injury is done a pulp by placing in such a cavity a filling of high conductivity, such as gold or amalgam. The patient often believes that ''cold water leaks in about the filling'' and may visit another dentist thinking that he has a poor piece of dentistry, and the patient may be lost to an otherwise good operator, all through the neglect of what may appear to the operator as a trivial matter.

The treatment of the first class is thorough disinfection followed by the application of phenol, full strength, for a few seconds. Then the cavity should be dried and it will be found unaffected by the blast of air from the chip-blower. The change is brought about by the superficial coagulation of the albumin in the exposed ends of the dental tubules which renders them nonconductive.

Second Class.—If, after one or two applications of the phenol as above, the distress from the blast of air is not relieved, or if the pain is continuous while the surface of the cavity is exposed to the air, it is probably of the second class as met with in the nearer approaches to the pulp. This class of cases demands a medium intervening between the dentine and the filling.

The treatment in the second class is as follows: Moisten the cavity with phenol and evaporate to comparative dryness. Then paint the entire dentinal walls with Calk cavity lining or copal and gum dammar in alcohol and ether solution. Such a preparation can be had at the dental depots or it can be prepared by the druggist. This should be thin and spread evenly, applying one, two, or three coats and drying with a draft of air from the chip-blower after each coat. When the varnish is entirely hardened the filling may be placed.

Third Class.—In the deep-seated stage of caries, where large quantities of dentine have been lost, even though the pulps may seem to be protected by secondary dentine that is much retracted, it is not safe to place a filling directly on the overlying dentine. The lost tooth structure should in a measure be replaced with a material which is a poorer conductor of thermal changes than dentine. This should be neutral as far as irritating properties are concerned, nonchanging, and should resist the force necessary to properly introduce the intended filling. Caulk pulp protector is recommended.

The treatment in the third class is as follows: Phenolize and dry. Varnish with the cavity varnish mentioned above and dry. Flow over the dentine, covering most if not all of the axial or pulpal wall, or both according to the class of cavity being treated, a thin layer of oxyphosphate of zinc cement, being careful not to include thereunder any air bubbles; also apply without pressure. Then allow this to set to complete hardness, when the filling may be completed. In the three classes given above it will be noted that coagulation of the protoplasm in the exposed ends of the tubules was the first step. This is good practice from the fact that this layer of coagulum is the least irritant to the remaining protoplasm of anything of which we have knowledge. Phenol is very limited in the extent of its action and this layer of coagulation is very thin. Again, with this third class, it will be noted that in addition to the use of the phenol the cavity is given a coat of varnish before applying the oxyphosphate of zinc cement. This procedure is to prevent the irritating effects of the phosphoric acid, particularly while the cement is setting. Again, should the zinc contain any impurities, their action on the pulp is prevented. One of the impurities of zinc is arsenic and some cements are thought to contain traces of this devitalizing agent. The cavity varnish given above is quite impervious to this element when it has been thoroughly hardened, a fact which should not be overlooked when it is desired to prevent the action of arsenic trioxide in a particular direction in a dental wall.

Fourth Class.—In deep-seated cavities where there is a slight pulp complication from thermal shock and where the thin overlying layer of dentine is probably infected to some depth and more deeply affected in the process of caries, the dentine should be subjected to quite a continued disinfecting process and a portion of the lost dentine restored with a poor conductor of heat to shield the pulp from sudden thermal changes.

The treatment in the fourth class of cases is as follows: The cavity should be flooded with a nonirritating antiseptic, as camphophenique, pure beechwood creosote, or oil of cloves. If sealed in the cavity for twenty-four hours, the result will be much better. The cavity should be then wiped dry with absorbent cotton and a thin paste of thymol and zinc oxide spread over the dentine overlying the pulp. Over this spread a layer of oxyphosphate of zinc cement and allow this to set hard before completing the filling.

In very questionable cases, the entire cavity may be completed with the cement, and the patient may be dismissed for six months, at the end of which time, if the pulp is found to be normal, a portion of the cement may be removed and replaced with a more permanent material.

Pulp preservers and so-called mummifiers should be avoided. Even their name is misleading and such preparations are used without permanent success in the majority of cases. Their use simply proclaims their users as unskilled laggards who will accept an uncertainty to avoid a little honest labor in pulp amputation and root filling. The entire procedure is diabolic and its condemnation cannot be couched in too severe terms. It is a retrogression in dentistry, and is unskilled in principle and unwarranted in practice.

Gutta-percha as a protecting covering is not a success from the fact of its great range of contraction and expansion under varying thermal changes. When enclosed under a perfectly tight and unyielding filling, as all fillings should be, the change in bulk must have a pistonlike effect upon the contents of the dental tubules resulting in continued irritation.

Sulfate of Zinc Pulp Capping.—A good pulp capping is made by thoroughly mixing 4 grains of the sulfate of zinc with 96 grains of plaster of Paris. This is mixed with warm water to the consistency of plaster for taking an impression. This paste is flowed over the nearly exposed pulp and allowed to set. Yet another reliable pulp capping is made from pure thymol and pure zinc oxide. The dentist can prepare these if he so chooses. Both have been on the market for many years, however, and are to be had at the dental supply houses.

Lastly, no filling should be placed which leaves the vital pulp exposed to any of its enemies, foreign substances, acids, or thermal shocks.

CHAPTER XXXVIII

PULPECTOMY WITH ANESTHESIA*

Terminology.—In 1921 the author suggested a nomenclature in published articles which is more in harmony with terms used for similar operations in other branches of surgery. It is well to define those terms here.

Pulpotomy is the term which designates the operation of cutting a pulp. (From the Greek *temnein,* to cut.)

Pulpectomy is the term which designates the operation of removing the pulp. (From the Greek *ektome,* excision.)

Partial pulpectomy is the term which designates the operation of removing part of the pulp. This may be either unavoidable or intentional.

Apicoectomy.—Excision of the apex of a tooth root. (Anthony.) (Latin, *apex,* the end, plus Greek *ektome,* excision.) A term long and correctly used.

These terms are shorter and are better form and more in harmony with the terminology of the other specialties, than are the descriptive sentences so long in use such as: ''Take out a part of the pulp,'' ''cut off the end of the root,'' ''kill the nerve,'' ''pulp extirpation,'' etc.

Instruments.—When a machinist, carpenter, or tradesman purchases tools, he is much interested in their working points, for upon their shape and size depends their fitness to accomplish the intended purposes. But how many dentists have ever looked at the working points of the canal instruments they have been buying, to say nothing about frequent examination of each and every instrument during their very short life. It has been too often the habit not even to look at the points when purchased, not to examine these delicate instruments following the most strenuous use, and to continue their use till each and every one breaks in a pulp canal. Then again, most pulp canal instruments as they are delivered to the dentist are very unsuited to accomplish the intended purpose. Those which are expected to be passed to the foramen are needle pointed and become engaged in a side wall at the first bend in the canal. All such points should be rounded like the end of one's fingers. (Fig. 272.) We need the following canal instruments for this work, each with the designated point and each in four to six sizes as to gauge, with a complete duplication of the set in short and long handles.

The list of instruments is as follows:

Pulp canal explorers, smooth broaches with rounded points.
Barbed broaches with rounded points.
Hatchet-pointed broaches for chopping.

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*The terms of Pulpotomy, Pulpectomy, and Partial Pulpectomy were proposed to the Dental Profession by the author for the first time in 1923, notably in the *Essentials of Operative Dentistry,* ed. 4, St. Louis, The C. V. Mosby Co., pp. 247-297. Also in *Dental Items of Interest,* the first nine issues of the year 1923, advocating the practice of partial Pulpectomy, which at the present time is quite generally taught in the dental colleges of America.

Apical curettes, with rounded points having the one and only barb near the end.

Pulp canal files and reamers with rounded points.

Pulp canal pluggers cut square across the end.

Pulp Devitalization.—The use of devitalizing agents such as arsenic cannot be too strongly condemned. Any attempted *pulpectomy,* may end as a *partial pulpectomy,* due to obstruction, bent canals, or lateral branches. If devitalization has been practiced, there must remain dead pulp tissue if inaccessible canals are present, which, together with the lack of aseptic precautions, has been the cause of nearly all of the postoperative pathology.

Pulp Anesthesia.—The pulp should be removed, while anesthesized, to near the mouth of the accessible foramen or the constriction which is normally found near the dentocemental junction in the canal.

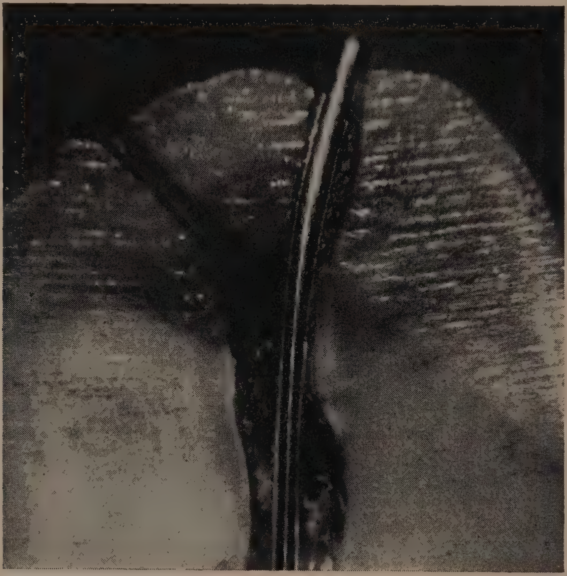


Fig. 272.—A sharp-pointed broach, as most broaches are when delivered, will not pass to either foramen. When rounded as above, it will pass each foramen at will of the operator.

Technic for Pulpectomy.—Take a radiograph of the tooth as the first of a series. (Fig. 273*A*.)

If block or infiltration anesthesia is to be used, attend to that, after which place the rubber dam.

Excavate the cavity and bathe with warm water.

Sterilize the cavity with ammoniated hydrogen peroxide. This is made by adding 4 drops of aqua ammoniae to 10 drops of hydrogen peroxide. This should be freshly mixed for each occasion of its use.

Pressure anesthesia, or general anesthesia, should be proceeded with at this time if block or infiltration anesthesia has not already been given.

Gain access to canal or canals by thoroughly removing all affected and infected dentine and enough of the roof of the pulp chamber to give a direct line of access to each canal.

Varnish cavity walls with two or three coats of a reliable cavity varnish and dry to hardness. This precaution is taken to prevent discoloration from the use of chemicals in treatment, or the combining of the iron of disintegrating blood with the protoplasm of the dental tubules, which later oxidizes producing discoloration.

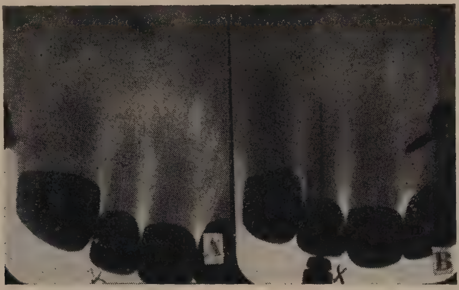
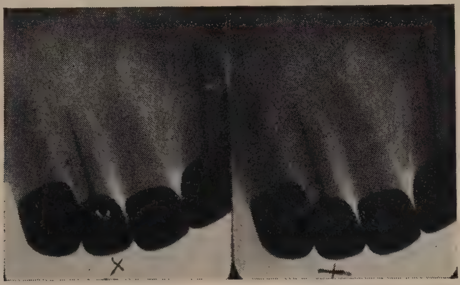


Fig. 273.—Clinical Case 411. *A.* X-ray before pulpectomy. *B.* X-ray of testing for length with broach.



A. *B.*

Fig. 274.—Clinical Case 411. *A.* X-ray of filled canal. *B.* X-ray three years after filling.

Pass a smooth broach, round of point, along by the side of the pulp, if possible to the constriction just short of the accessible foramen. This explorer should carry a disk of rubber dam which may be so placed as to mark the depth of penetration. These disks are cut with the largest hole cutter in the rubber dam punch. Each broach subsequently used should have a rubber disk placed on it to correspond with the depth marked on the explorer.

Pass a small barbed broach to the distance marked on the explorer by the rubber disk. Give the barbed broach a half to a full turn clockwise and withdraw. The broach should carry the amputated pulp. If it does not, repeat the operation till the pulp is withdrawn. A larger barbed broach should be used in large canals.

Bathe the canal with warm water following pulp removal and dry with paper canal points. Never enter a pulp canal with cotton wrapped on a broach with the fingers. This is one of the causes of many failures in the past, due to infection. No irritating or caustic drugs should be used in the canal. The pulp wound or wounds should be left with as little trauma or irritation as possible, if we are to expect the usual repair. Formaldehyde, creosote, sulfuric acid, and chlorazene have no place in pulp canal work.

Flood the canal with your favorite nonirritating anodyne antiseptic, pumping it to the pulp stump as shown by the depth-marking rubber disk. Next, make some of this fluid into a paste with bismuth subnitrate, adding iodine, and pump this paste to the pulp wound. The writer uses the same canal dressing as in treating putrescence. A canal dressing containing bismuth subnitrate will show white wherever it has been placed.* (Fig. 276.) To assist in getting this to the pulp stump use a round-ended pulp canal reamer just about the caliber of the canal, and when using the pumping motion turn the reamer counterclockwise. The canal should be filled with a rather heavy mixture.

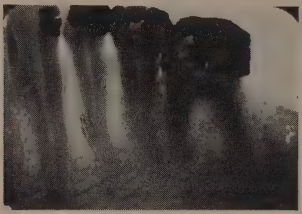


Fig. 275.

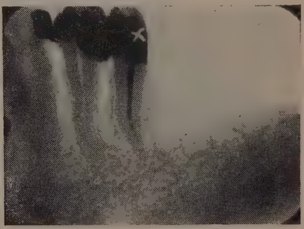


Fig. 276.

Fig. 275.—Clinical Case 301. X-ray of lower second bicuspid before pulpectomy.
Fig. 276.—Clinical Case 301. Canal dressing following pulpectomy.

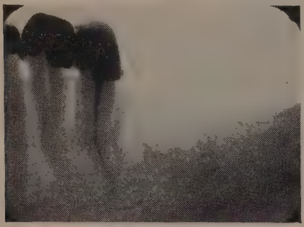


Fig. 277.

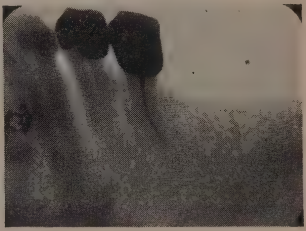


Fig. 278.

Fig. 277.—Clinical Case 301. X-ray shows canal filled.
Fig. 278.—Clinical Case 301. X-ray of seventh checkup eleven years after pulpectomy.

Clear away all excess from the cavity to below the gum line. Fill the cavity with hot sticky temporary stopping, being sure not to create any pressure on the vital pulp stump or stumps, as pain and pericemental soreness or even the loss of the pulp stump may result.

Take a radiograph for the series and to learn at what point the pulp has been excised. (Fig. 276.) Dismiss the patient for two or three days.

Canal Filling Following Pulpectomy.—The pulp has been removed as described, and the patient has returned two or three days later for the canal filling. Place the rubber dam. Remove the temporary stopping. Flood the canal with camphophenique, and with reamers and paper canal points remove all of the canal dressing. The depth gauge as previously described on page 331 will assist in preventing injury to the pulp wound near the foramen. When the canal has been thoroughly reamed smooth and made dry, a gutta-percha point of a size to fill the canal and of a length to come just short of the pulp wound is fitted. The returned sensation to the pulp stump at foramen will assist in adjusting the length. (Fig. 273, *B*.)

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*Bismuth subnitrate shows white in the x-ray (negative) and black in the prints published, which are positives.

Next, flood the canal with Calahan varnish to which has been added sufficient dithymoldiiodide to render varnish visible in the x-ray. Take the previously measured gutta-percha point from a bath of spirits of chloroform with 1 grain mercuric chloride to the ounce added, and pass into the canal to a point short of the stump of the pulp, at the foramen. Allow this to remain from three to five minutes for partial solution, and then, with a slight pumping motion, seat as near the vital tissues as possible without causing pressure pain. Take a radiograph as a third in the series. Filling may yet be moved closer to the foramen if so desired. Cut off surplus point level with the cervix and cover with a white cement. (See Figs. 275 to 278.)

CHAPTER XXXIX

PARTIAL PULPECTOMY, UNAVOIDABLE OR ACCIDENTAL

Definition.—Pulpotomy is defined as any operation on the dental pulp. Pulpectomy is that which designates the entire removal of the pulp. Partial pulpectomy means the partial removal of the pulp. We have been taught, have believed, and ourselves have taught that the recuperative powers of the pulp were practically nil. It would seem that this is in error and that, in case the pulp is not overwhelmed by bacteria, it is above the average of the other tissues of the body in its ability to withstand surgical treatment, that it undergoes repair in a perfectly orderly manner, and that this repair is in harmony with the general process of the repair of other connective tissues.

Requisites for Pulp Repair.—Pulp repair depends upon the action of vital living cells and a continuous supply of nutriment, as with any other tissue repair. It is not surprising, therefore, to find no cases of pulp repair following pulp devitalization with arsenic, or where tissue-destroying drugs or chemicals have been used after attempted pulp extirpation. It should be remembered that the pulp tissue does not extend to the several foramina, but that it meets the pericemental tissue some distance within each orifice. Pulp tissue and pericemental tissue are both connective tissue.

They differ physiologically as well as histologically, however, and their genetic cells produce different tissues. Pericemental tissue builds cementum and ages with the other tissues of the body. The pulp builds dentine but early senility is a pulp idiosyncrasy. The repair of traumatized pericemental tissue results in simple connective scar tissue, which is the case with other connective tissue similarly situated. The repair of pericemental tissue is normal as to time required. With the traumatized pulp following pulpotomy the process of repair is slow. The cause is probably inherent. The pulp early in life becomes semidormant, and awakens from its senile lethargy only for the repair of injury to that tissue or to the dentine, the tissue the pulp has built.

When the injury to the pulp is of such a nature that its genetic cells, the odontoblasts, are left vital particularly in the bulbous portion, the repair is accomplished by the odontoblasts, and adventitious dentine results. This repair is expected following the operation known as "capping the pulp." The dental profession has long relied on this fact and expected secondary dentine as a protective measure. Many pulps have been so long subjected to enemies, however, that degenerative changes have involved the coronal, or bulbous portion to a degree that the odontoblasts have been destroyed or so weakened as to no longer function. Such cases demand a clean amputation of at least the bulbous portion of the pulp.

This leaves the pulp with a wound in which there are no odontoblasts. We must rely on the connective tissue cells for repair. The usual process of the formation of a connective tissue scar develops. As previously indicated, the process is slow. Long-drawn-out repair is favorable to a tissue metaplasia. The normal function of the pulp is the construction of a calcified tissue, which is an additional explanation of this metaplasia.

Pathology.—Following the operation of partial pulpectomy there takes place within the pulp stump the same series of changes which occur in other connective tissue in the formation of a connective tissue scar. In addition, there frequently follows a tissue metaplasia wherein this scar tissue is changed to an osteoid tissue without going through the granulation tissue stage. When this tissue metaplasia takes place, the pulp canal is obliterated at the seat of the wound much as the medullary canal is closed following amputation of the long bones. This repair tissue is pathologic tissue.

All repair tissue in the body is pathologic tissue and remains pathologic tissue through life, as it is abnormal tissue. No repair tissue in the body is ever completely regenerated. This repair depends upon the activity of vital living cells, and certain well-known conditions must obtain if we are to expect repair. The pulp must be a vital pulp. This precludes any attempt at pulp "mummification," because the first step in pulp mummification involves the destruction of the vitality of the pulp. The tissue allowed to remain must be such as would permit the healing of any tissue. The circulation must be vigorous as indicated by a good hemorrhage at the time of the operation.

The infection must not be so great as to be beyond the ability of the leucocytes in the blood stream to readily master. The tissue left in the canal must not be lacerated at any great distance from the point of excision. A small blood clot must be allowed to remain on the wound to assist in establishing the collateral circulation at the seat of the wound. The dressing, temporary or permanent, must be placed without pressure on the pulp stump, that it may not interfere with the free circulation of blood. The dressing should not contain fluids which are blood solvents or blood diluents, as these will disturb or destroy the blood clot. If a hemostatic is used, it must be of such nature that it will not destroy the blood clot or the tissue of the wound, which would invite sloughing of the pulp tissue.

As a hemostatic we advise Squibb's Thromboplastin (local), as this will in no way interfere with the subsequent reorganization of the blood clot. The above conditions and others we could mention are essential to the healing of any wound in connective tissue, and are not peculiar to the operation of partial pulpectomy.

Histology.—The cases which have been examined show two distinct classes: those which have persistent vital pulp stumps, and those wherein the pulp canal has been filled with the new osteoid tissue from near the end of the root canal filling to the foramina. With the first class there is complete closure of the canal at the seat of the wound. This is accompanied many times by a building in of osteoid tissue about the pulp in concentric rings which has gradually lessened the lumen of the canal.

This lessened lumen extends from the end of the root filling, apexwise, to near the largest foramen, whereas the lateral canals may be completely closed to near their exits. The complete closure of these lateral canals takes place early in the process.

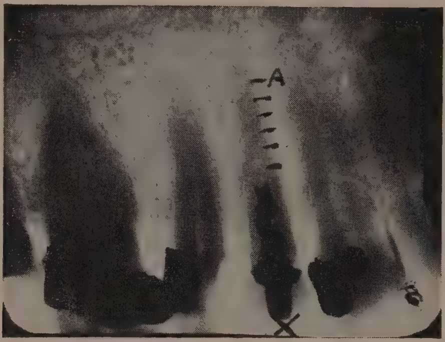

Fig. 279.—Case 141. Radiograph of superior first bicuspid taken before extraction. This tooth proved to have but one root canal which is an exception for the superior first bicuspids. This single canal shows distinctly in the center of the root. Several teeth including this one were extracted on account of pyorrhea.

What brought the patient to the infirmary, however, was the presence of an exposed pulp in the second bicuspid just posterior to tooth examined. We could get no history of the case from the patient's dentist. The patient described a clear case of pressure anesthesia and immediate crowning about ten years previous to the date of extraction, which was May 10, 1920. Condition of the pulp at the time of crowning the tooth was not entirely clear. The patient remembered, however, that the tooth pained him when he "got some food in the tooth."

Several sections were made of the root from the apex to the oxyphosphate of zinc cement with which the post of the crown was surrounded. Six sections are shown with section "A" beginning at the apex, each being shown in several magnifications. The vital pulp was present in the central portion of the canal which had been largely filled with osteoid tissue, built in concentric rings about the pulp. The pulp was probably active in the deposition of osteoid tissue at the time of extraction.

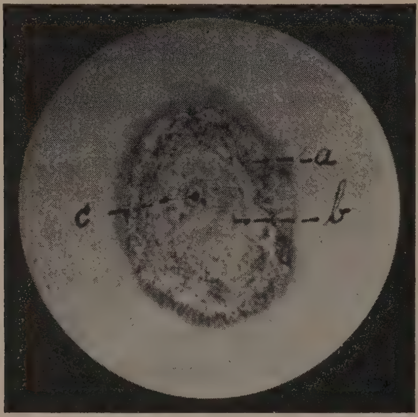

Fig. 280.

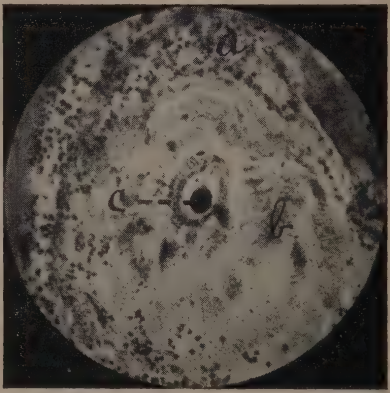

Fig. 281.

Fig. 280.—Case 141. Section A. This section was taken from near the apex of the root. *a.* Cementum. *b.* Dentine. *c.* Pulp. (Magnification ×20.)

Fig. 281.—Case 141. Section A. *a.* Cementum. *b.* Dentine. *c.* Pulp. (Magnification ×50.)

With the second class of cases there is a complete closure of the pulp canal from the end of the partial canal filling to near the exit of the pulp at each of the foramina. This tissue metaplasia ceases at the point where the pulp tissue meets the periodontal membrane, which is a short distance within the mouth of each one of the foramina.

Some writers seem to have gained the idea that we may expect a closure of the foramina. That is, a leveling up of the mouths of the foramina flush with the external surface of the root without the pulp tissue above having first been completely obliterated. They have misunderstood or else we have not made it clear that this would be an impossibility. If the building in of this

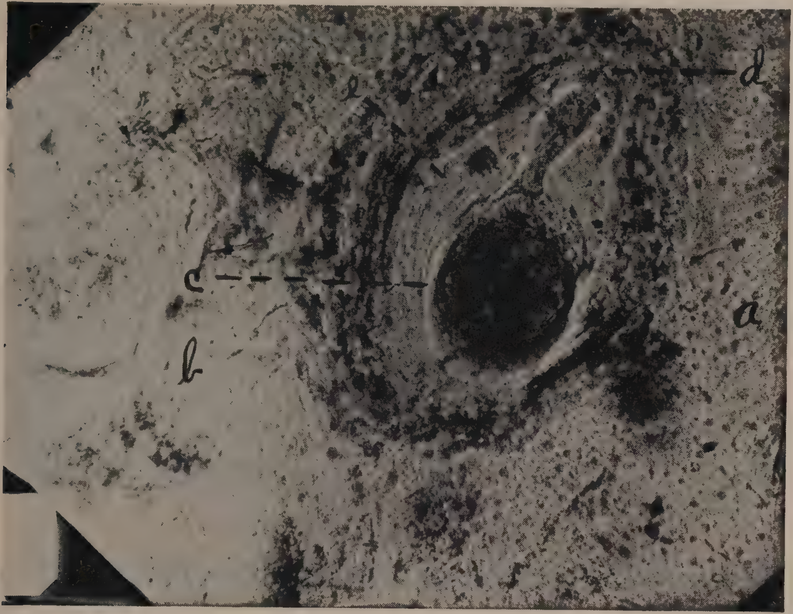

Fig. 282.—Case 141. Section A. *a.* Cementum. *b.* Dentine. *c.* Pulp. *d.* Cementum lining pulp canal. *e.* Osteoid tissue. (Magnification ×320.)

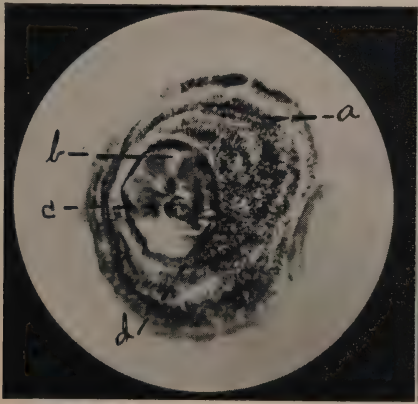

Fig. 283.

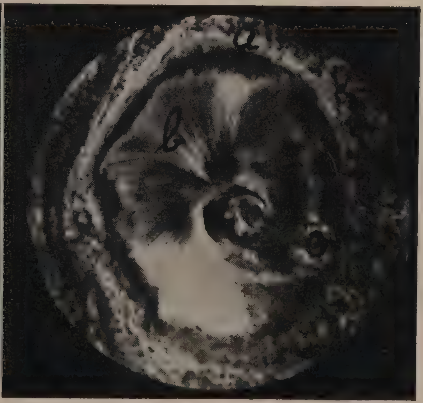

Fig. 284.

Fig. 283.—Case 141. Section B. *a.* Cementum. *b.* Dentine. *c.* Pulp canal. *d.* Lateral canal. (Magnification ×50.)

Fig. 284.—Case 141. Section B. *a.* Cementum. *b.* Dentine. *c.* Lateral canal. (Magnification ×50.)

osteoid tissue was primarily done from near the mouth of the foramina, the pulp tissue crownwise from that portion would die and all efforts at repair would cease at the time the lumen of the canal became so restricted as to cause the death of the pulp. Nature does not build new tissue on dead tissue.

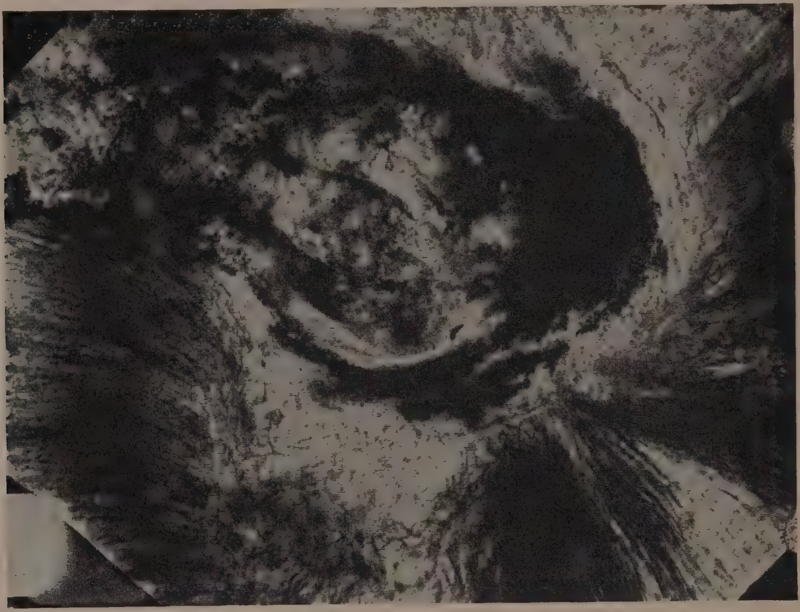

Fig. 285.—Case 141. Section B. (Magnification ×320.)

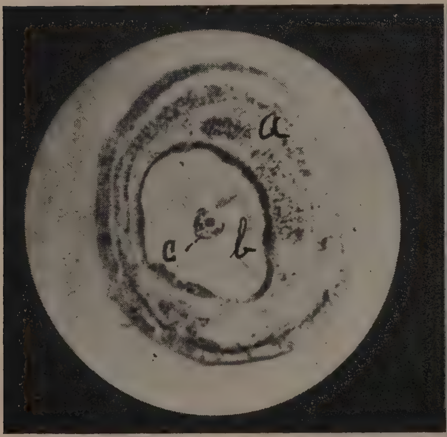

Fig. 286.

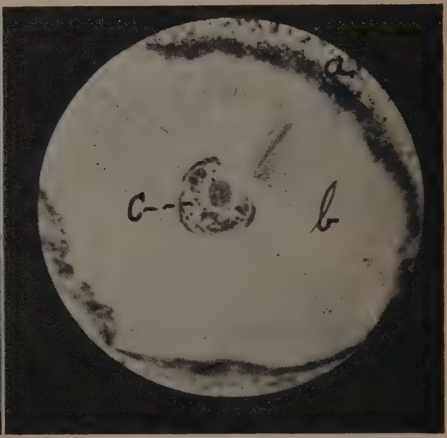

Fig. 287.

Fig. 286.—Case 141. Section B. *a*. Cementum. *b*. Dentine. *c*. Pulp canal. (Magnification ×20.)

Fig. 287.—Case 141. Section C. *a*. Cementum. *b*. Dentine. *c*. Pulp containing osteoid tissue with vital pulp tissue in the center. (Magnification ×50.)

Our study of these cases shows that the primary building of the osteoid tissue is near the seat of the wound and progresses from that point rootwise. It begins at the position most distant from the blood supply and ceases altogether when the periodontal tissue in the foramina has been reached. This fact should indicate that our wound must be in pulp tissue if we are to expect this transformation, which means that in partial pulpectomy we must excise the pulp crownwise from the dentocemental junction in the canal.

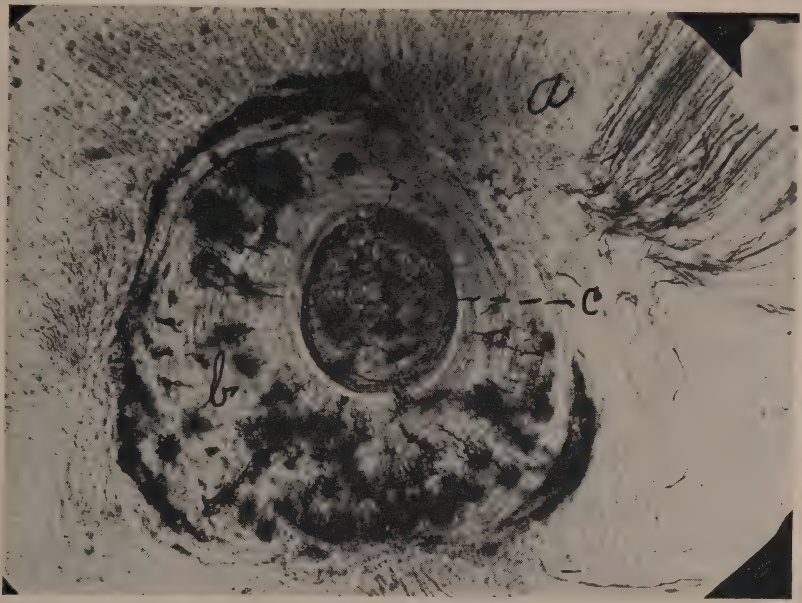

Fig. 288.—Case 141. Section C. *a.* Dentine. *b.* Osteoid tissue lining the canal. *c.* Vital pulp tissue. (Magnification ×320.)

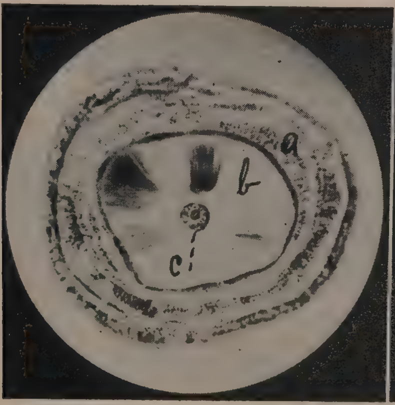

Fig. 289.

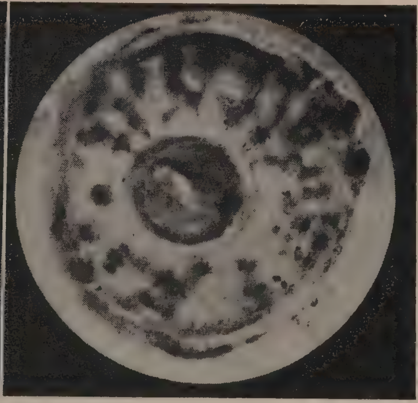

Fig. 290.

Fig. 289.—Case 141. Section D. *a.* Cementum. *b.* Dentine. *c.* Pulp canal. (Magnification ×20.)

Fig. 290.—Case 141. Section D. (Magnification ×50.)

To illustrate that class of cases (90 per cent) wherein the pulp has remained vital, we show cross sections of a root wherein this osteoid tissue is formed in concentric rings about the pulp. (See Figs. 280 to 296.) Note the cells (lacunae and canaliculi), characterisitic of bone. In other cases (about 10 per cent) there was complete obliteration of the canal. This class of cases is illustrated in Figs. 297 to 307. It is quite possible, where closure was not complete at the time of extraction, that pulp calcification would have gone on to complete canal obliteration had the tooth been allowed to remain longer in the mouth.

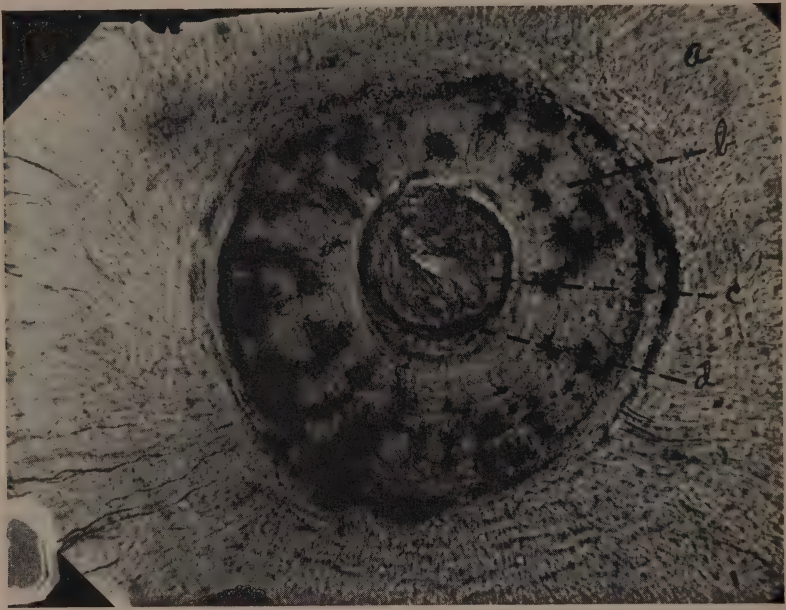

Fig. 291.—Case 141. Section D. *a*. Dentine. *b*. Osteoid tissue lining canal. *c*. Pulp tissue. Note the dark stained ring (*d*) which seems to be the external layer or coating of the pulp. It should be noted that this osteoid tissue (*b*) has been built in concentric rings. In this as well as many of the other sections from this and other teeth, the lacunae and canaliculi are distinctly shown.

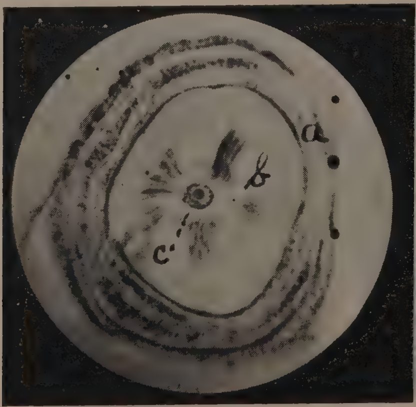

Fig. 292.

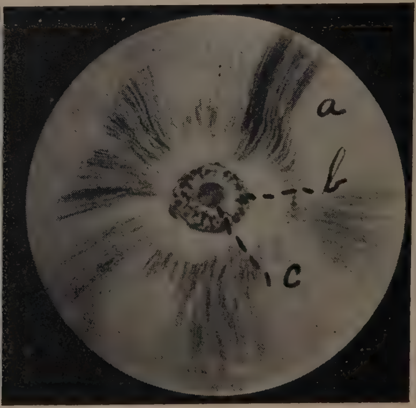

Fig. 293.

Fig. 292.—Case 141. Section E. *a*. Cementum. *b*. Dentine. *c*. Pulp canal. (Magnification ×20.)

Fig. 293.—Case 141. Section E. *a*. Dentine. *b*. Osteoid tissue. *c*. Pulp tissue. (Magnification ×50.)

Independent Action as to Roots.—It would seem that after the bulbous portion of the pulp of a multiple rooted tooth has been removed, each pulp stump becomes a law unto itself as to vital action or disease, and is governed by the individual environment as distinctly as though the roots were of different teeth.

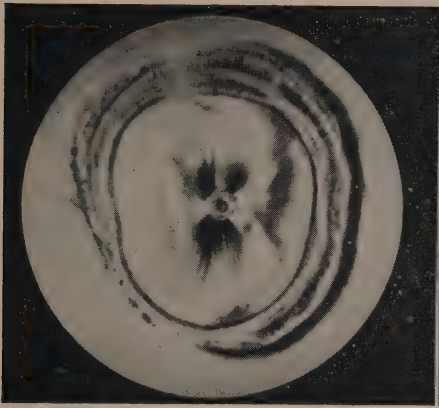

Fig. 294.

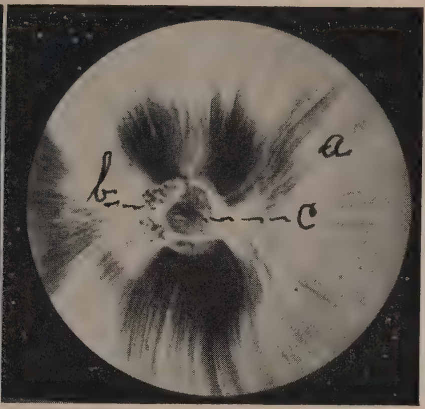

Fig. 295.

Fig. 294.—Case 141. Section F. *a.* Cementum. *b.* Dentine. *c.* Calcified scar tissue filling pulp canal. (Magnification ×20.)

Fig. 295.—Case 141. Section F. *a.* Dentine. *b.* Osteoid tissue. *c.* Calcified scar tissue. (Magnification ×30.)

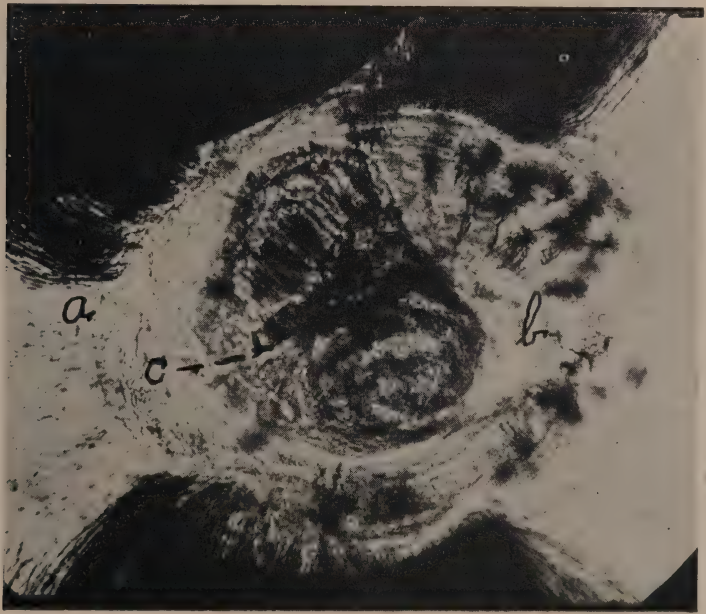

Fig. 296.—Case 141. Section F. *a.* Dentine. *b.* Osteoid tissue. *c.* Calcified scar tissue. This section was taken from just above the point of the pin which was a part of the crown. It was calcic matter as proved by the hydrochloric acid test. In the previous sections shown, the central portion of that which was once the pulp canal was filled with connective tissue, and would not effervesce upon the application of dilute hydrochloric acid. (Magnification ×320.)

Diagnosis.—The selection of our cases for partial pulpectomy and partial root filling should be made only after a very careful diagnosis of each case, that we may determine the condition of the tissue in the canals from the crown to the root end. With symptoms of active hyperemia only, it may be safe to amputate the bulbous portion of the pulp. With symptoms of passive hyperemia the point of amputation should be farther rootwise, as the wound should not be laid in a congested area.

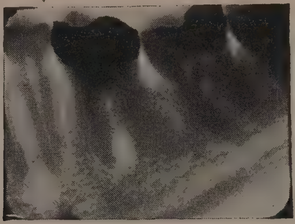

Fig. 297.—Case 157. Radiograph was taken before extraction. Patient's name was not secured. Tooth furnished by Dr. F., who reported case came to him in December, 1904, in a semiputrescent condition. The mesial canals were fully putrescent. These were treated and filled with a medicated cement. The fluid part of this cement was largely oil of cloves. The powder of the cement was composed largely of zinc oxide.

The distal root contained a vital pulp, and this medicated cement had been placed over the stump at the level of the floor of the pulp chamber, and the tooth filled on the above date. It will be seen that the mesial canals remain infected. A large granular mass about the mesial root was the cause of the tooth's final extraction in January, 1920, or sixteen years after the operation. Note the tissues about the distal root and the seeming absence of any canal.

A portion of the pulp which was allowed to remain in the distal root must have been more or less infected, and the upper portion of it, no doubt, was in some of the stages of inflammation. From this it would seem that slight infection and inflammation are not barriers to the operation of partial pulpectomy, as recovery, then repair, and finally transformation of the pulp have taken place in this as well as other similar cases previously shown. This result, however, should not be taken as an argument for careless operating as to aseptic surgery, but, if repair does take place in septic cases where the excision has been made through inflamed tissue, what may we not expect from surgically clean cases with the wound made in comparatively normal tissue?

Closure of this canal is most complete from the floor of the pulp chamber near the mouth of the foramen. The mouth of the foramen, however, and there was only one in this case, was open for a distance about equal to its breadth, which is where the periodontal membrane usually joins pulp tissue.

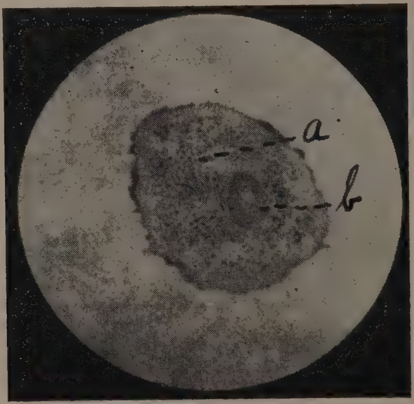

Fig. 298.—Case 157. Section A. *a*. Cementum. *b*. Dentine. (Magnification ×20.)

Again, when we have indications of neuroparalysis, the operation should invariably be high in the apical third. Neuroparalysis is indicated by the

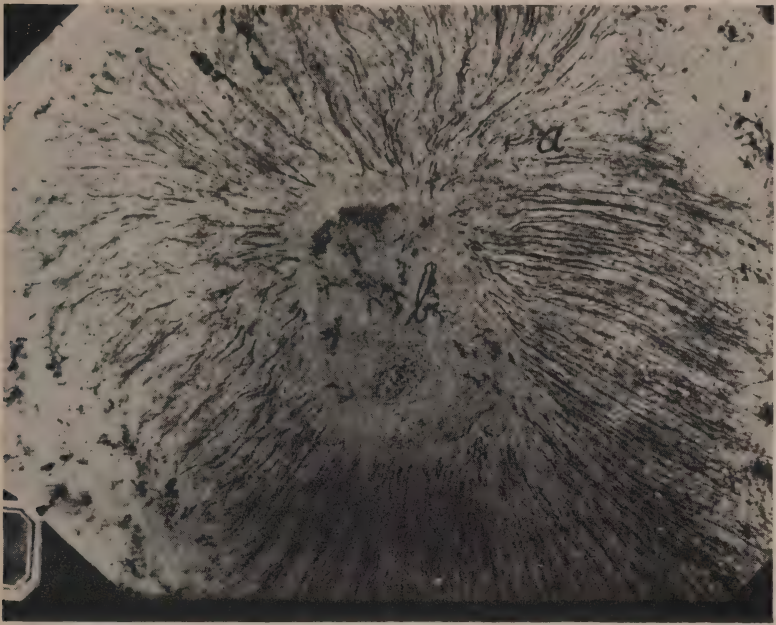

Fig. 299.—Case 157. Section A. *a.* Dentine. *b.* Osteoid tissue filling the canal. (Magnification ×320.)

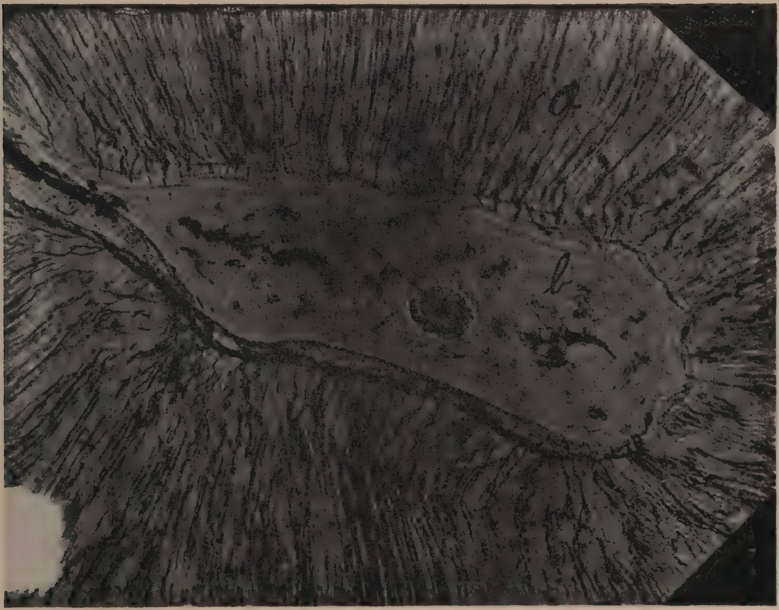

Fig. 300.—Case 157. Section B. *a.* Dentine. *b.* Osteoid tissue. *c.* Remains of calcified artery. (Magnification ×320.)

increase of pain upon the patient assuming the recumbent position, but which is relieved upon again assuming the erect posture. When the tooth is sore to percussion, in addition to the symptoms of passive hyperemia, the case goes over into the putrescent or semiputrescent class, which is given consideration in Chapter XLI.

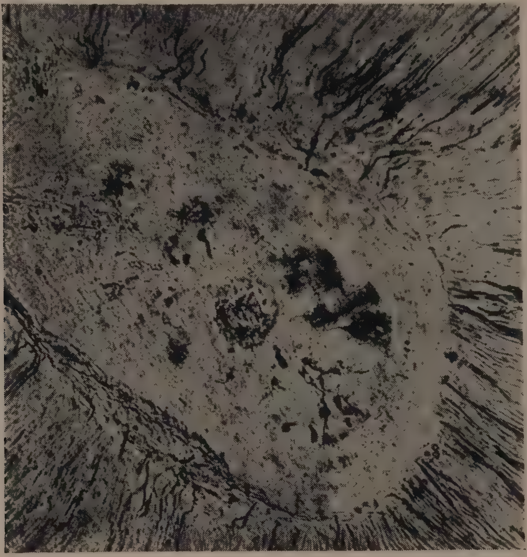

Fig. 301.—Case 157. Section C. *a.* Dentine. *b.* Osteoid tissue. *c.* Remains of calcified artery. (Magnification ×320.)

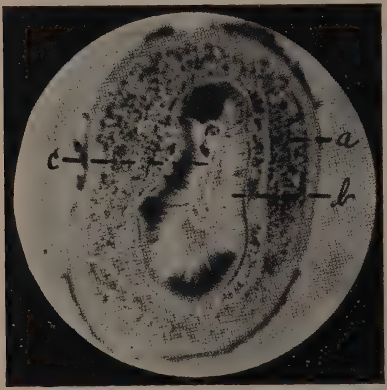

Fig. 302.

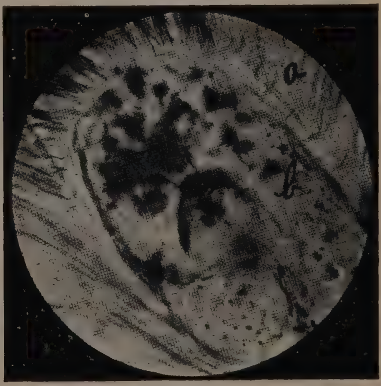

Fig. 303.

Fig. 302.—Case 157. Section D. *a.* Cementum. *b.* Dentine. *c.* Entirely closed pulp canal. (Magnification ×20.)

Fig. 303.—Case 157. Section D. *a.* Dentine. *b.* Osteoid tissue filling the canal. (Magnification ×50.)

Pulpectomy Is the Operation of Choice.—The complete removal of the pulp is not always possible, however, due to (1) lateral branches from inaccessible canals leading to foramina where instrumentation is impossible, (2) canal obstruction, and (3) crooked roots. (Figs. 308 to 311.)

When these inaccessible portions of the canals are left filled with vital living pulp tissue, with a clean wound, and an unimpaired circulation, and the remaining pulp tissue has not been traumatized or poisoned with escharotics, we may expect to get a connective tissue repair of the pulp wound, and, through a tissue metaplasia, have the formation of an osteoid tissue which may plug the canal near the seat of the amputation. Further calcification may

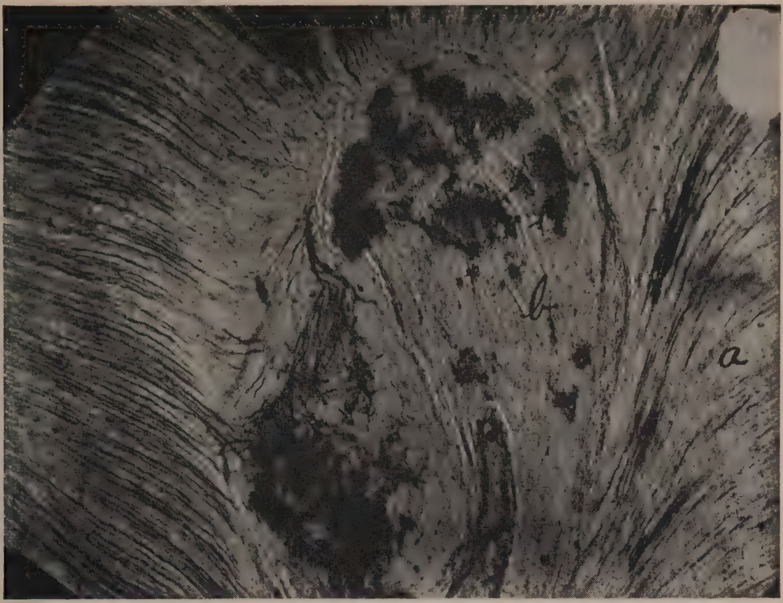

Fig. 304.—Case 157. Section D. *a.* Dentine. *b.* Osteoid tissue. (Magnification ×320.)

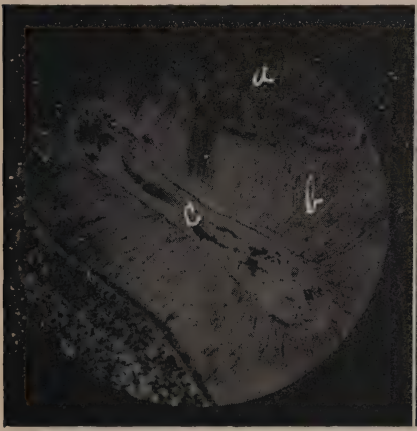

Fig. 305.

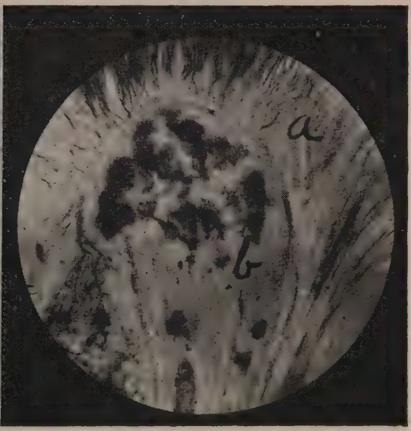

Fig. 306.

Fig. 305.—Case 157. Section E. *a.* Cementum. *b.* Dentine. *c.* Osteoid filling pulp canal. (Magnification ×20.)

Fig. 306.—Case 157. Section E. *a.* Dentine. *b.* Osteoid tissue. (Magnification ×50.)

materially lessen the lumen of these canals, even to complete obliteration from the point of amputation to the mouth of all foramina. (Figs. 312 to 321.)

Requisites for Pulp Repair.—Pulp repair depends upon the action of vital living cells and a continuous supply of nutriment, as with any other tissue

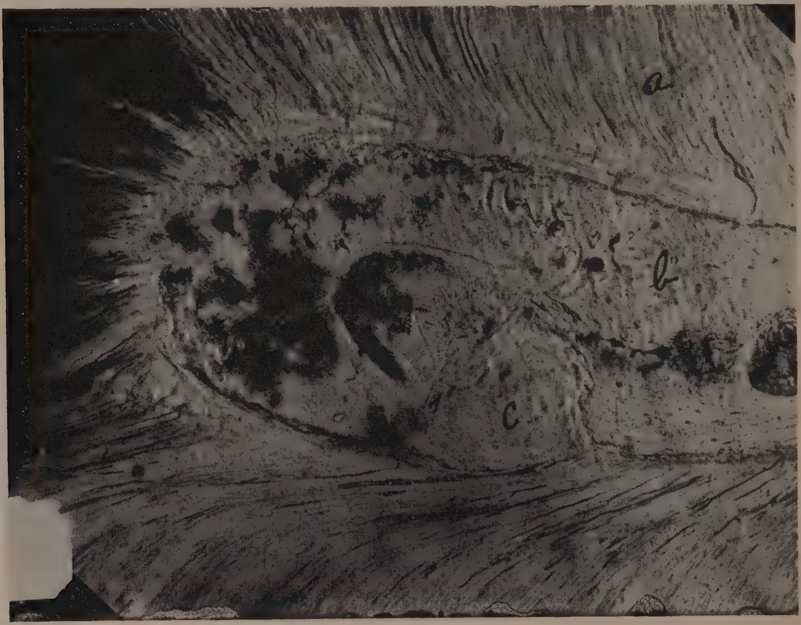

Fig. 307.—Case 157. Section E. *a.* Dentine. *b.* Osteoid tissue. *c.* Pulp nodule. It is very probable that this pulp nodule was in position at the time of the beginning of the calcification of the pulp. (Magnification ×320.)

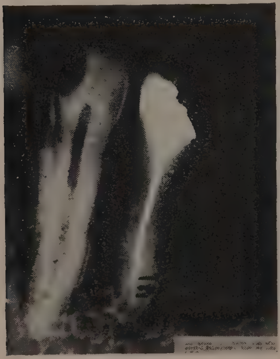

Fig. 308.

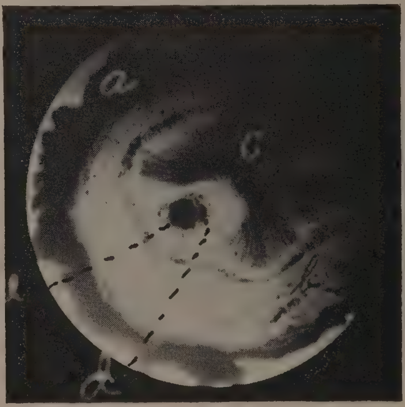

Fig. 309.

Fig. 308.—Laboratory Case 175. X-ray* taken eleven years after an unintentional partial pulpectomy. Tooth was extracted and sectioned from the apex to the gutta-percha canal filling. Three sections are shown.

Fig. 309.—Laboratory Case 175. Section A. *a.* Periodontal membrane. *b.* Cementum. *c.* Dentine. *d.* Osteoid tissue. *e.* Pulp. (Magnification ×30.)

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*Enlarged to show as a negative.

repair. It is not surprising, therefore, to find no case of pulp repair following complete pulp devitalization with arsenic, or where tissue destroying drugs or chemicals have been used after attempted pulpectomy. It should be remembered that the pulp tissue does not extend to the several foramina, but that it meets the pericemental tissues some distance within each orifice at the junction where the dentine ends within the canal. Pulp tissue and pericemental tissue are both connective tissue.

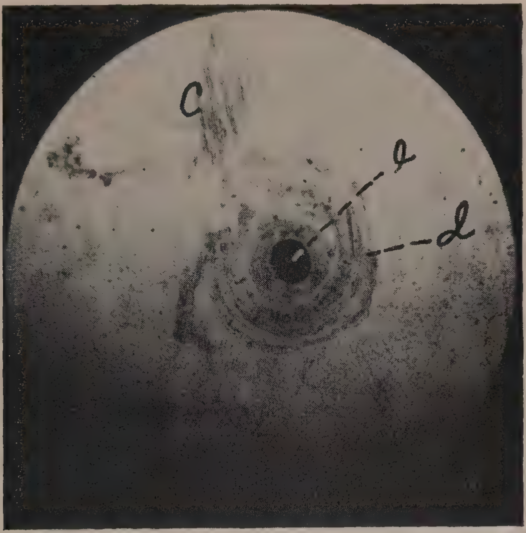


Fig. 310.—Laboratory Case 175. Section B. *c.* Dentine. *d.* Osteoid tissue. *e.* Pulp. (Magnification ×50.)

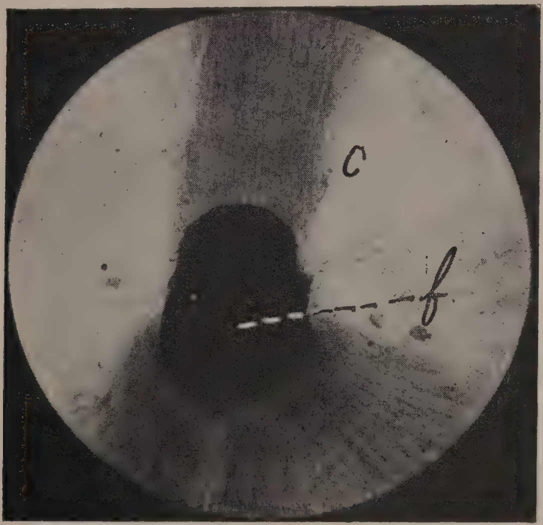


Fig. 311.—Laboratory Case 175. Section C. *c.* Dentine. Tip of gutta-percha canal point. (Magnification ×50.)

They differ physiologically as well as histologically, however, and their genetic cells produce different tissues. Pericemental tissue builds cementum and ages with the other tissues of the body. The pulp builds dentine but early senility is a pulp idiosyncrasy. The repair of traumatized pericemental tissue results in simple connective scar tissue, which is the case with other connective tissue similarly situated. The repair of pericemental tissue is normal as to time required. With the traumatized pulp following any pulpotomy the process of repair is slow. The cause is probably inherent. The pulp early in life becomes semidormant and awakens from senile lethargy only for the repair of injury to that tissue or to the dentine, the tissue the pulp has builded.

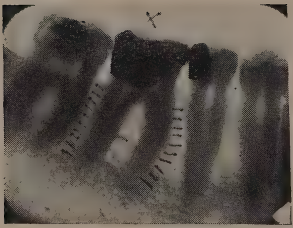


Fig. 312.

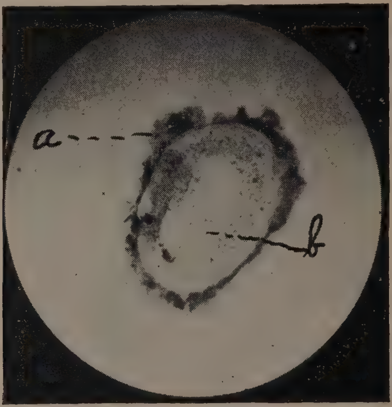


Fig. 313.

Fig. 312.—Laboratory Case 155. X-ray and case history. Aged 23 years. Patient not in best of health. Physician ordered tooth removed, which was protested by his dentist. The operation of partial pulpectomy had been done nine years previously when the boy was 14 years old. The two wounds of the pulp were covered with a cement largely composed of zinc oxide and oil of cloves, and restoration was made of amalgam. Patient had never had any sensation in or about the tooth. The periodontal tissues seemed as healthy as those about the adjacent teeth. This tooth was prepared and a series of twenty sections of each root microphotographed by the author, a few of which are shown here.

Fig. 313.—Laboratory Case 155. Section A. Distal root. *a.* Pericementum. *b.* Solid cementum. Main foramen had been closed. (Magnification ×20.)

When the injury to the pulp is such that its genetic cells, the odontoblasts, are left vital particularly in the bulbous portion, the repair is accomplished by the odontoblasts, and adventitious dentine results. This repair is expected following the operation known as "capping the pulp." The dental profession has long relied on this fact and expected secondary dentine as a protective measure. Many pulps have been so long subjected to enemies, however, that the degenerative changes have involved the coronal, or bulbous portion to a degree that the odontoblasts have been destroyed or so weakened as to no longer function.

The author's laboratory technic for preparing the sections shown in this chapter follows.

1. Fix in Zenker's fluid, 12 to 14 hours immediately following extraction.

Zenker's formula:

Potassium bichromate	2.5 Gm.
Sodium sulfate	1.0 Gm.

Corrosive sublimate	5.0 Gm.
Glacial acetic acid	5.0 Gm.
Water	100.0 Gm.

2. Wash in running water 12 to 24 hours.
3. Alcohol, 50%—6 to 12 hours.
   Alcohol, 70%—6 to 12 hours.
   Alcohol absolute—6 to ? hours.
4. Xylol at least 24 hours and allow to remain for future use.
5. Melted paraffin, 48 c.c.—1 to 4 hours.
6. Water till sectioned.
7. Saw in thin sections and wash.

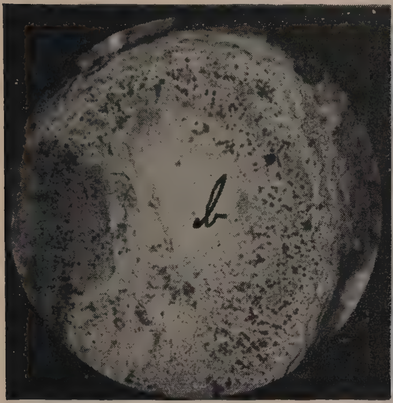


Fig. 314.

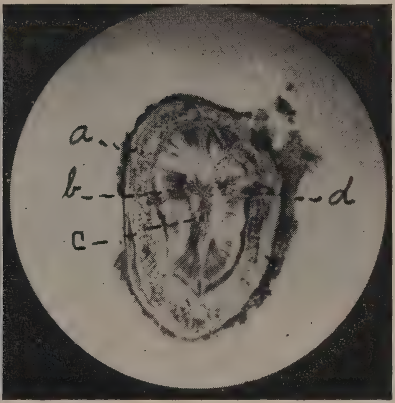


Fig. 315.

Fig. 314.—Laboratory Case 155. Section A. Distal root. *b.* Cementum. (Magnification ×30.)

Fig. 315.—Laboratory Case 155. Section B. Distal root. *a.* Cementum. *b.* Dentine. *c.* Secondary dentine in main canal. *d.* Lateral canal filled with osteoid tissue. (Magnification ×20.)

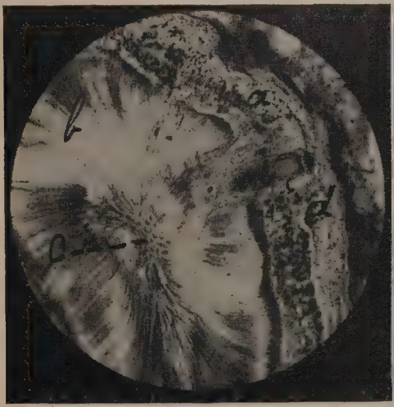


Fig. 316.

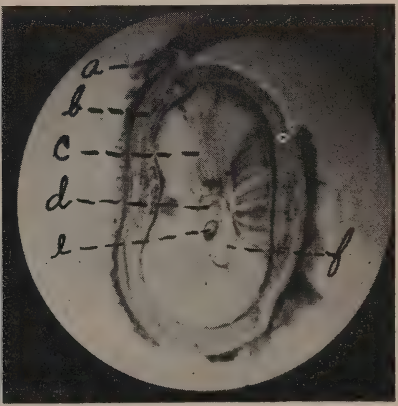


Fig. 317.

Fig. 316.—Laboratory Case 155. Higher power on Section B. Distal root. *a.* Cementum. *b.* Dentine. *c.* Secondary dentine in main canal. *d.* Lateral canal osteoid tissue. Magnification ×30.)

Fig. 317.—Laboratory Case 155. Section D. Distal root. *a.* Pericementum. *b.* Cementum. *c.* Dentine. *d.* Osteoid tissue. *e.* Pulp tissue (remains) saturated with lime salts. *f.* Calcic material with the structure of a pulp nodule. (Magnification ×20.)

8. Grind to thickness desired and wash. This grinding was done by placing the thinly cut sections between the surfaces of two fine Arkansas stones, each about 2 by 7 inches. With the section between these stones they are moved back and forth much after the older method of polishing marble. The section is frequently removed and examined under the microscope until the desired thinness is secured. When the section is approaching extreme thinness, care must be taken as it is possible to grind to such degree that the section disappears.

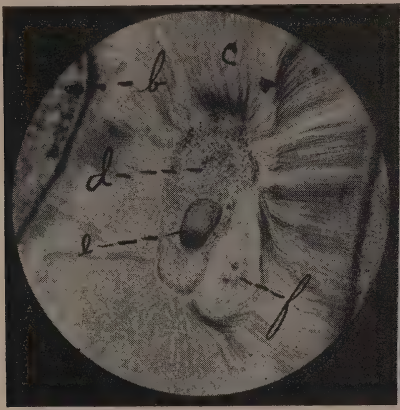


Fig. 318.

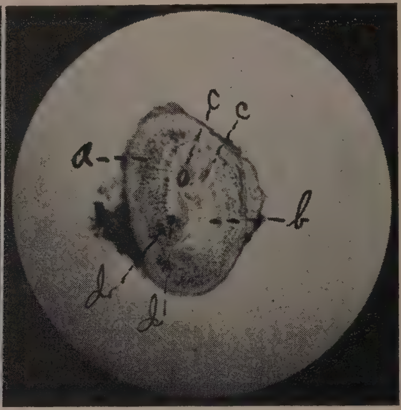


Fig. 319.

Fig. 318.—Laboratory Case 155. Higher power on Section D. Distal root. *b.* Cementum. *c.* Dentine. *d.* Osteoid tissue. *e.* Pulp tissue saturated with lime salts. *f.* Calcic material with the structure of a pulp nodule. (Magnification ×30.)

Fig. 319.—Laboratory Case 155. Section A. Mesial root. *a.* Cementum. *b.* Dentine. *cc.* Pulp tissue. *dd.* Osteoid tissue. (See higher power, Fig. 320.) (Magnification ×20.)

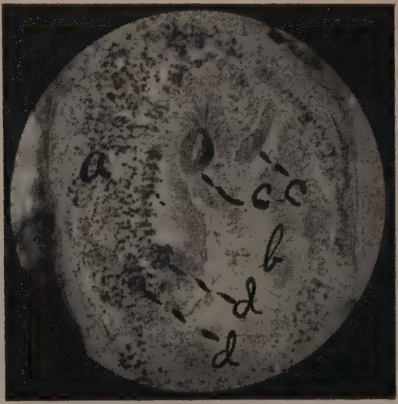


Fig. 320. Laboratory Case 155. Section A. Mesial root under higher power. *a.* Cementum. *b.* Dentine. *cc.* Pulp proved connective tissue. *dd.* Osteoid tissue closed canals. (Magnification ×30.)

9. Place in absolute alcohol 1 minute.

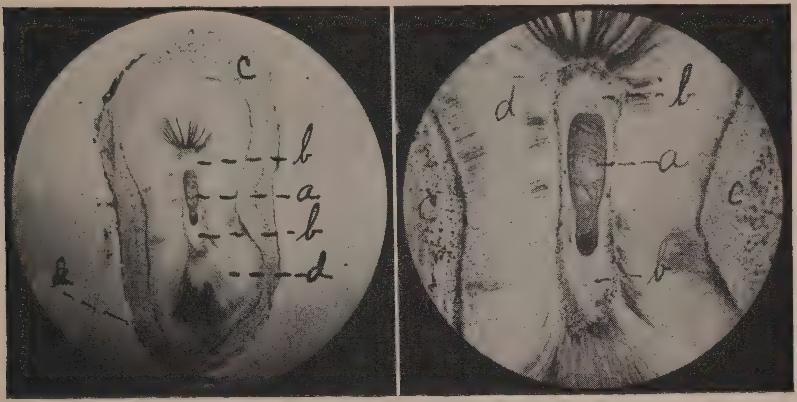
10. Xylol 30 minutes to remove paraffin.

11. Alcohol 2 minutes to remove xylol.

12. Wash in water five minutes stirring with spatula. This will clear all spaces and parts of the canals which have been filled with putrescent matter.

13. Remove section and treat with a blast of air from chip-blower or compressed air. This will remove all unattached particles.

14. Place section on slide and watch under microscope while it drys in the air. This will generally take about a minute. If there is any connective tissue it will shrink and will be seen to draw away from one side leaving a space or it may split.
15. Dehydrate in alcohol for 5 minutes.
16. Stain in eosin (1 per cent aqueous solution 2 minutes).
17. Wash in water to free of stain granules.
18. Alcohol 10 seconds to remove surface stain.
19. Place in carboxylol 5 minutes or longer until mounted.



A. *B.*

Fig. 321.—Laboratory Case 155. Section H. Mesial root.

A. Low power. *a.* Pulp tissue saturated with unorganized calcic matter. *bb.* Osteoid tissue. *c.* Cementum. *d.* Dentine. This section is from near the floor of the pulp chamber. (Magnification ×20.)

B. Higher power. *a.* Pulp tissue saturated with unorganized calcic matter. *bb.* Osteoid tissue. *cc.* Cementum. *d.* Dentine. (Magnification ×30.)

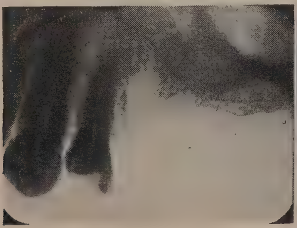


Fig. 322.

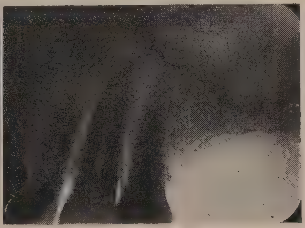


Fig. 323.

Fig. 322.—Clinical Case 298. X-ray before partial pulpectomy.
Fig. 323.—Clinical Case 298. X-ray shows dressing in place.

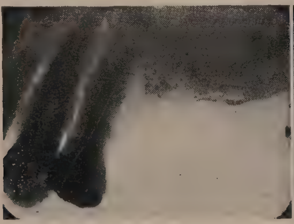


Fig. 324.

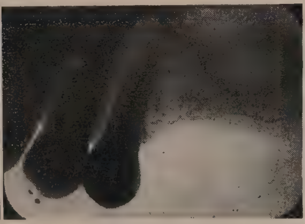


Fig. 325.

Fig. 324.—Clinical Case 298. X-ray shows canals filled two days after partial pulpectomy.
Fig. 325.—Clinical Case 298. X-ray shows condition four years after partial pulpectomy.

Canal Filling Following Unavoidable Partial Pulpectomy.—(1) Where lateral branches exist, their presence is not known by the operator, and of necessity the filling of the main canal would be done as in any case of pulpectomy or supposed complete pulp removal. (2) When the pulp has been removed to, or amputated at, a canal obstruction, or (3) when a crooked canal is encountered, either of which has forced a partial pulpectomy as previously described, the filling of the canal to the obstruction is not a difficult matter; however, extra aseptic precautions are necessary.

Fig. 326.

Fig. 327.

Fig. 326.—Clinical Case 336. X-ray before partial pulpectomy.
Fig. 327.—Clinical Case 336. X-ray shows testing for pulp wound.

Fig. 328.

Fig. 329.

Fig. 328.—Clinical Case 336. X-ray shows canal filled following partial pulpectomy.
Fig. 329.—Clinical Case 336. X-ray shows case three years after partial pulpectomy.

Technic.—Place the rubber dam. Sterilize the field. Flood the canal with camphophenique. This thins the dressing, so that it may be wiped away. Dry the cavity with paper points. Fit canal point to place of obstruction and put in 70 per cent alcohol or spirits of chloroform till needed. Flood canal with canal varnish and place canal point near to point of obstruction and let it remain for a few minutes to allow the chloroform in the varnish to attack the gutta-percha point. Then, with a pumping motion proceed to partially dissolve the point and seat the entire mass against the obstruction and in contact with the pulp stumps. (Figs. 322 to 329.)

CHAPTER XL

PARTIAL PULPECTOMY, INTENTIONAL (OR AMPUTATION)

Intentional partial pulpectomy is the operation of choice in the permanent undeveloped teeth of children as well as in their deciduous teeth when the pulps of these teeth become involved, as it is not possible to make a satisfactory or safe canal filling in such teeth.

The yet undeveloped roots of the permanent teeth generally have a foramen larger than the canal at any place crownwise, and the deciduous teeth have roots that are progressively being resorbed.

In Permanent Teeth of Children

When Indicated.—Partial pulpectomy (or amputation) is indicated in the permanent teeth of children when the pulp of a tooth with yet undeveloped root or roots has been so exposed through decay or traumatic injury that its future vitality is in serious danger. In case the pulps of such teeth are allowed to pass on to death and putrescence, they must be operated on for apicoectomy following canal filling or be extracted, as a satisfactory canal filling is impossible due to a flaring foramen.

Through early decay the first permanent molars and occasionally the second permanent molars often have their pulps exposed before the roots are fully formed. Through their large foramina courses a strong circulation to assist in repair and to render existing infection only temporary.

Technic of Partial Pulpectomy on Partially Developed First Molars.—Anesthesia is obtained by either nerve block or slight pressure, or by sealing novocain in the cavity for a few hours.

Take an x-ray as the first of a series that should be made of all pulp cases.

Flood the cavity with oil of cloves to which has been added 5 per cent phenol, which is not caustic.

Thoroughly expose the pulp by removing entirely either the axial or pulpal wall.

Check hemorrhage with the application of more of the oil of cloves and phenol compound.

To amputate the bulbous portion of the pulp, pass a very sharp No. 20 spoon excavator to the side of and beneath the pulp bulb, and sever the three branches at the floor of the pulp chamber and remove the excised bulb.

Bathe pulp stumps in hot water. If hemorrhage is profuse, pack pulp chamber with a hot tampon (a pledget of cotton from boiling water). With the hemorrhage under control, wipe the cavity dry and again flood the pulp chamber with the oil of cloves and phenol compound and allow to remain, while making a thick paste of zinc oxide 98 per cent, bismuth subnitrate 2 per cent, with pure oil of cloves. Dry the cavity and flow this paste over all the pulp stumps to the depth of about one millimeter. After this, fill the balance of the pulp chamber with oxyphosphate of zinc cement. The late Dr. Drain, of the University of Iowa, suggested, "It would be well if all would use a brown copper cement to remind us of the operation of pulp amputation." When this cement is fully set the tooth may be contoured with either an inlay or amalgam. Condensing of foil fillings over undeveloped roots is contraindicated. An x-ray is taken as the second of the series. "Checkup" x-rays should be made every few months till the roots are fully developed.

The several pulp canals will be closed for a short distance below the point of amputation, but the pulp will generally remain vital and the canals of normal lumen to the ends of normally developed roots. Cases are met with, however, wherein the deposits, begun at the wound, have continued to the complete obliteration of the canal.

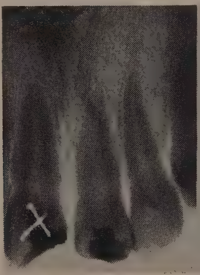


Fig. 330.

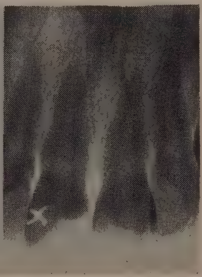


Fig. 331.

Fig. 330.—Clinical Cases 374 and 375. Day of fracture before the operations of partial pulpectomy. Patient, a boy, 13 years old. Anesthetic, nerve block.

Fig. 331.—Clinical Cases 374 and 375. X-ray taken same day, following operations, showing fillings complete.

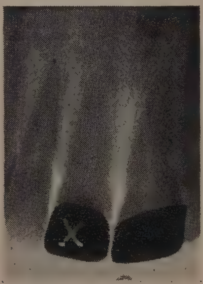


Fig. 332.—Clinical Cases 374 and 375. X-ray taken four years after operation of partial pulpectomy on teeth with large foramina, found in youth.

Single-Rooted, Undeveloped Permanent Teeth.—Traumatic exposure of a pulp in the permanent central and lateral incisors of children is a common accident, but it is easily handled by amputating the pulp. Before the roots of these teeth are fully formed, the foramen is large, much larger than the canal leading thereto. Pulpectomy and attempts to fill such foramina are contraindicated. In case the amputation is postponed and the pulp becomes putrescent in an undeveloped root, the tooth may be lost as attempts at correct and complete canal filling and even at apicoectomy may be followed by sustained pathology.

Fig. 333.

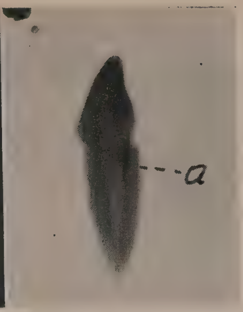


Fig. 334.

Fig. 333.—Laboratory Case 180. This case was found in the practice of Dr. C. J. Whitney, of Concordia, Kansas. This young man had been in an accident 18 years previously in which he had received a complete diagonal fracture of the mandible which was not compound. The fracture healed in due time. The x-ray shows the tooth had again united. The tooth was extracted, mailed to the author, and again x-rayed post extraction as shown in Fig. 334.

Fig. 334.—Laboratory Case 180. The tooth was prepared and sectioned using the technic as outlined in the chapter just previous, that we might study the scar tissue and possibly determine the source of this repair work. The remains of the pulp was a shriveled-up dry mass showing death from dry gangrene. The pulp chamber was closed at the wound. A longitudinal section was made as indicated by line (*a*).

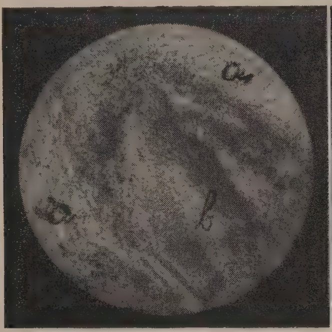


Fig. 335.

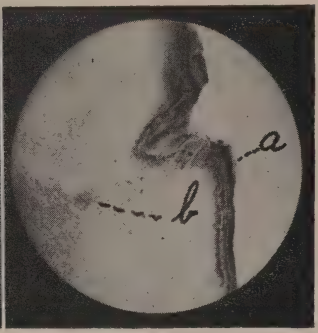


Fig. 336.

Fig. 335.—Laboratory Case 180. Photomicrograph of scar tissue in the center of union of the fractured tooth. *aa*. Dentine. *b*. Scar tissue of the cementum. (Magnification ×180.)

Fig. 336.—Laboratory Case 180. A Photomicrograph, low power, at edge of fracture showing the dipping in of the pericementum which was instrumental in the repair. *a*. Pericementum. *b*. Line of repair.

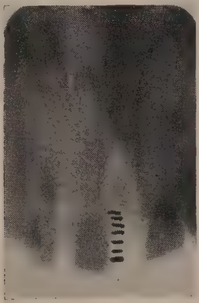


Fig. 337.—Laboratory Case 176. Upper central incisor from the mouth of a private patient 64 years old. He had an end-to-end bite, hence much incisal wear. All teeth were removed to make room for full dentures. His history was as follows: When a boy 13 years old attending school at a country schoolhouse, during a game of hockey the four central incisors were knocked clear of their sockets and he spit them out. The teacher picked them up and without washing them placed them back in their sockets and bandaged his jaws shut. The teeth grew solid and had never ached or been sore since.

The author examined the teeth, which proved vital. The color was as clear as that of the lateral incisors to electric light transmission. X-ray showed all four teeth to be normal. The teeth were extracted and placed immediately in Zinkeres fixing solution and passed through the steps shown in the previous chapter, to the microscope, and photographed. Twelve sections of the right superior central incisor are shown.

Technic of partial pulpectomy in undeveloped single-rooted teeth is not unlike that just described for molars. (Figs. 330 to 332.)

Take an x-ray as the first of a series. Secure anesthesia. Place rubber dam. Bathe broken surface with oil of cloves and phenol compound. Thoroughly expose the pulp. With a very keen new bur slightly larger than the canal, amputate the coronal portion level with the cervix. Bathe the pulp stump with warm water. Check hemorrhage as described in case of molar.

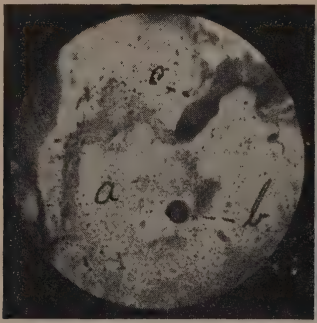


Fig. 338.

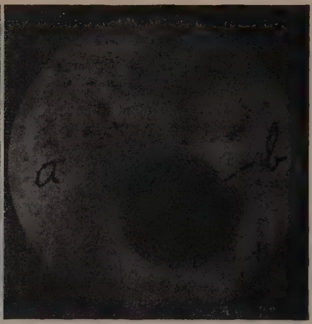


Fig. 339.

Fig. 338.—Laboratory Case 176. Section A. Right superior central incisor near the apex. *a.* Cementum. *b.* Pulp. *c.* Foramen. (Magnification ×20.)

Fig. 339.—Laboratory Case 176. Section A, higher power. *a.* Cementum. *b.* Pulp. (Magnification ×50.)

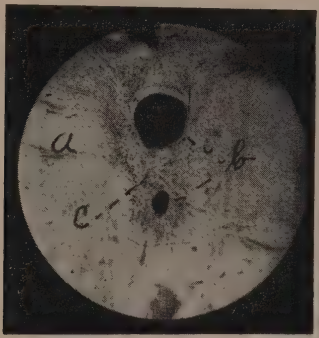


Fig. 340.

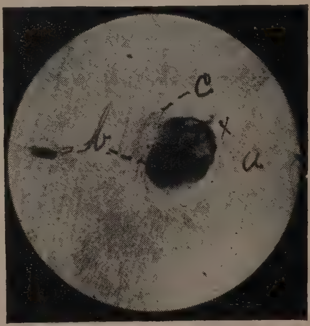


Fig. 341.

Fig. 340.—Laboratory Case 176. Section B. *a.* Dentine. *b.* Pulp canals. *c.* Osteoid tissue. (Magnification ×20.)

Fig. 341.—Laboratory Case 176. Section C. *a.* Dentine. *b.* Pulp canals. *c.* Osteoid tissue. (Magnification ×20.)

Dry and flood with oil of cloves and phenol compound. Cover stump of the pulp with about one millimeter of the zinc oxide, bismuth subnitrate and oil of cloves paste, without pressure.

Over this, place a layer of brown oxyphosphate zinc cement and complete with the indicated restoration, temporary or permanent. The writer generally covers with a pure gold cap for a few years. The pulp and pericementum will continue to function for the completion of a normal root. Surgical cleanliness is imperative. Do not use pure phenol on the stump of any amputated pulp in permanent teeth of child or adult. It is no place to use an escharotic. Phenolization of the pulp stump is good practice in the deciduous teeth as we do not expect a constructive repair.

In Deciduous Teeth of Children

Partial pulpectomy (or amputation) is indicated in all deciduous teeth wherein there is a recently exposed pulp.

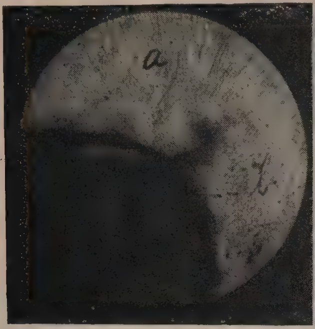


Fig. 342.

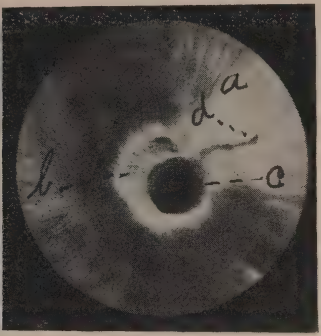


Fig. 343.

Fig. 342.—Laboratory Case 176. Section C, higher power of Fig. 341 at *x*. *a*. Dentine. *b*. Pulp tissue. (Magnification ×50.)

Fig. 343.—Laboratory Case 176. Section D. *a*. Dentine. *b*. Adventitious dentine. *c*. Pulp tissue. *d*. Lateral canal calcified. (Magnification ×20.)

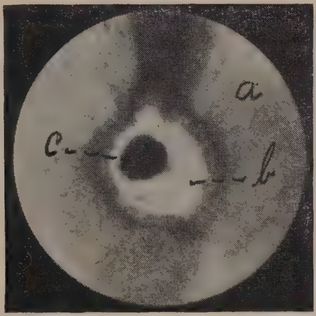


Fig. 344.—Laboratory Case 176. Section E. *a*. Dentine. *b*. Adventitious dentine. *c*. Pulp tissue. (Magnification ×20.)

Technic.—Place the rubber dam. Desensitize with novocain. Completely uncover the pulp chamber. Repeatedly bathe the pulp with oil of cloves. With a very sharp spoon excavator amputate and remove the coronal portion of the pulp. Check bleeding with hot tampons. Render as dry as possible and touch up all pulp stumps with phenol, which must not be used to excess.

Over this apply a heavy mix of zinc oxide and oil of cloves of about one millimeter thickness.

Cover this with a layer of brown copper cement, and proceed to make the desired restoration.

In case the pulp is not again exposed through decay or trauma, the roots of these temporary teeth will continue to a normal resorption without discom-

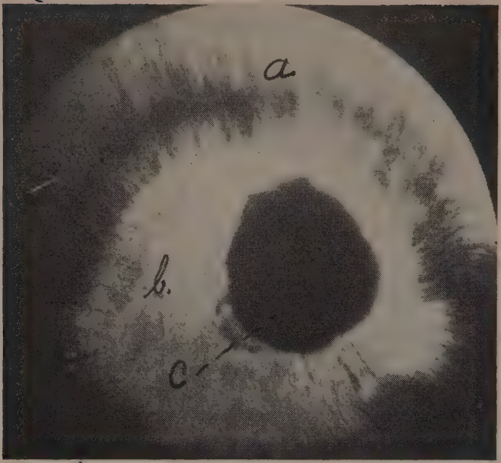


Fig. 345.—Laboratory Case 176. Section E, higher power. *a.* Dentine. *b.* Adventitious dentine. *c.* Pulp tissue. (Magnification ×50.)

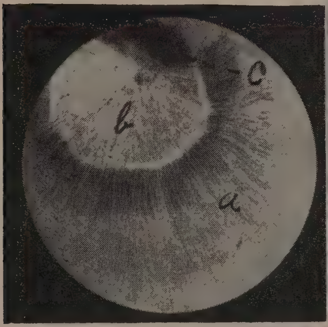


Fig. 346.

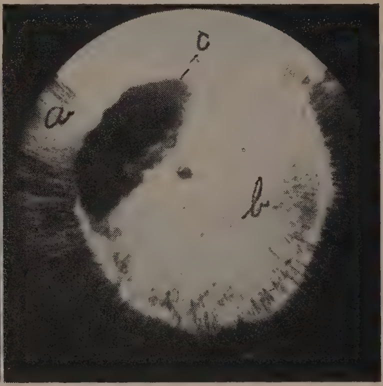


Fig. 347.

Fig. 346.—Laboratory Case 176. Section F. *a.* Dentine. *b.* Adventitious dentine, *c.* Pulp tissue partly calcified. (Magnification ×20.)

Fig. 347.—Laboratory Case 176. Section F, higher power. *a.* Dentine. *b.* Adventitious dentine. *c.* Pulp tissue partly calcified. (Magnification ×50.)

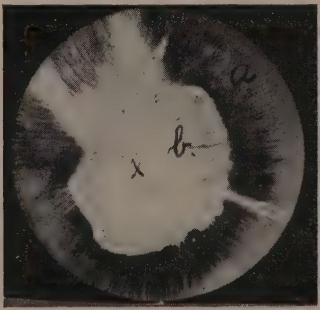


Fig. 348.

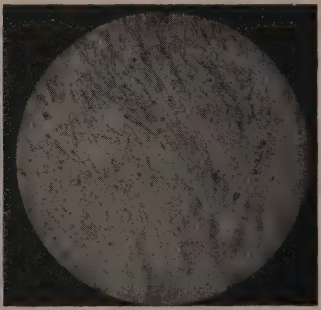


Fig. 349.

Fig. 348.—Laboratory Case 176. Section G. *a.* Dentine. *b.* Adventitious dentine. (Magnification ×20.)

Fig. 349.—Laboratory Case 176. Section G, higher power of Fig. 348 at *x* showing adventitious dentine sprinkled with uncalcified connective tissue cells. (Magnification ×180.)

fort to the patient or indications of infection. In case the pulp of a deciduous tooth has become partially or totally putrescent, its management is given in a subsequent chapter. (See Chapter XLVIII.)

In cases where the permanent teeth of children are knocked entirely from the mouth, they should be replanted at the earliest possible moment. If pathology develops, treat as other cases of pathology. If convenient, it is well to do the canal filling out of the mouth and replant under an anesthetic, with as sterile conditions as possible, applying a retaining splint. When tissue is approximated to like tissue soon after separation, and in the absence of infection, first intention healing is nearly assured even in the cases of tooth fracture (see Figs. 333 to 336) or complete dislocation of the tooth. The accompanying figures are cases in point on which complete checkup was made as to history and a histopathologic laboratory study was made by the author. (See Figs. 337 to 349 inclusive, with legend.)

CHAPTER XLI

PULP PUTRESCENCE, SIMPLE

Clinical Divisions.—In the classification given in Chapter XXXVII we have divided the putrescent cases into Simple and Complicated. The simple are those wherein all x-ray, clinical, and physical manifestations of putrescence or infection seem to be housed in the pulp canal.

The complicated cases are those wherein there is evidence that the subdental tissues are involved as a sequence of the pulp canal condition. (See Chapters XLII and XLIII.)

In 1923, at the time of writing the fourth edition of *Essentials of Operative Dentistry,* the author approached the subject of the management of putrescent pulp canals and complications resulting therefrom with much caution, and suggested that each teacher would do well to continue his personal investigation and regard what was given at that time as only suggestive.

Because of the uncertainty and the lack of time to prove facts, many practitioners and some dental colleges became ''100 per centers'' with the motto of ''Safety first'' and advised the extraction of all teeth, the pulps of which were involved.

Twenty years more of research and its practical application by the leading dental colleges of America and Europe and of interested individuals of ability and scholastic attainments have so far advanced the fundamental knowledge relative to infection in the teeth and in the bones of the face that such a condition is now dealt with along similar lines of procedure as are infections in other bones and tissues of the body.

Putrescence Defined.—By putrescent pulp canals is meant that condition in these spaces resulting from putrefaction. Putrefaction is a fetid decomposition of dead nitrogenous substances; a breaking up of the proteins, induced by the growth of certain bacteria.

A distinguishing feature of the process is the evolution of malodorous gases such as NH_3, H_2S, and such typical decomposition products as skatole (C_9H_9N) and indole (C_8H_7N).

There are three conditions necessary to bring about putrefaction: (1) The presence of bacteria. (2) Moisture. (3) The temperature not above 90° C. (194° F.) nor below 5° C. (41° F.).

The relation between defective teeth and ill health has been established. That many of the diseased conditions about the teeth are the sources of trouble rather than the sequelae has long been known and is fully appreciated. Our sense of well-being, health, and our very lives depend on keeping infection within our bodies below the balance of bodily resistance. It follows that happiness, health, and long life are fostered by bringing the resistance to the maximum and by lowering infection to the minimum.

It is very probable that no fixed rule can with safety be applied to every case, as there are many factors which must be taken into consideration and which are more or less remote from the individual tooth under consideration. Much depends on the physical condition of the patient.

Cooperation.—The helpful attitude of all physicians, dentists, and people sick or well, should be to eliminate infection wherever or whenever possible to do so, and not to inflict a greater injury in the process. The pathologic and biologic problems involved are no more difficult as regards these tissues than with similar structures in the body with which the physician deals daily. They are connective tissue and bone.

At the same time the individual tooth under consideration may be only a very small part of the problem in that individual case. For that reason, in the clinics of our large universities, the lesions in the sick wherein the breaking point has been passed are serious, and time is an element of success, surgery without delay being routine practice. The teeth are removed and the adjacent tissues are curetted at one or more sittings properly spaced. In the surgical management of these cases, however, the operator should be mindful of the effects of the reaction following the opening of the blood stream to increased doses of infection to which the patient may have been sensitized.

All of these cases must be approached with these facts in mind, and antiseptic measures and precautions are paramount from the beginning of the case to its termination, that the pericementum may not become involved if it has not already taken on destructive process. The presence of the above-mentioned foul-smelling gases in putrefaction assist, clinically, in diagnosing a case of putrescence, and determining the extent to which the condition has been overcome in the course of treatment.

It is the pulp tissue within the canals which may become putrescent. Putrefaction of the albumin in the dental tubules also takes place, and may extend to the dentoenamel and the dentocemental junctions.

The pulp tissue must be dead before putrefaction begins. The entire pulp may die and the pulp canals rendered putrescent to their several endings. The pulp may undergo a slow death from surface ulceration, followed by molecular decomposition, so that only a part of the pulp canal may be found putrescent with the remaining portion occupied by vital pulp tissue.

Divisions and Diagnosis.—Simple putrescence may be divided clinically into two divisions, open and closed.

Simple open putrescence is diagnosed by:

First, the fact that there exists an opening from the cavity to the pulp chamber.

Second, the presence of malodorous decomposition products.

Third, the absence of vital pulp tissue.

Simple closed putrescence is diagnosed by:

First, the absence of sensation in cutting the dentine.

Second, the fact that warm fluids or air cause increased pain, which is relieved temporarily by the application of cold air or fluids.

Third, the fact that on opening the pulp chamber, temporary relief is generally immediate.

The opening into the pulp canals may involve the removal of tooth substance, or a filling, or even a partial pulp canal filling previously placed.

Simple open putrescence may become complicated putrescence at any time, or may exist for many years without involving the subdental tissues and without causing the patient any inconvenience or attracting the attention of his dentist.

Simple closed putrescence, as a rule, soon becomes a case of complicated putrescence because of the transmission of infectious processes to the periapical tissues.

Treatment of Simple Open Putrescence.—X-ray the tooth before deciding procedure. This will serve as the first of a series which should be established and maintained for years following as an education to the operator, a protection to the patient, and an aid to dentistry as a whole in accumulating facts about a problem that has all but ‘‘floored it’’ and a subject about which many dentists know and care little.

Place the rubber dam. Sterilize the field exposed. For that purpose one may use a 10 per cent solution of formaldehyde, to which has been added a small amount of borax or alcohol 91 per cent, chloroform 9 per cent, with 1 grain bichloride of mercury to the ounce added. Mechanically remove the contents of the pulp chamber and flood the open cavity with ammoniated peroxide. (Ammonia 4 drops, hydrogen peroxide 10 drops, mixed fresh each sitting.) Repeat several times, or until active effervescence ceases, then wash with hot water. Again flood the cavity with the ammoniated peroxide and, with a small round-ended barbed broach or a canal reamer turned clockwise, proceed mechanically and chemically to cleanse the first two-thirds or three-fourths of the pulp canal. Again wash with hot water and dry.

Next, apply a drop of pure aqua ammoniae to the canal and again wash with water and dry, using paper points and warm air. The pulp chamber should be given two or three coats of cavity varnish to prevent discoloration.

In some cases in simple putrescence where the destruction has not been complete, there may remain small shreds of vital sensitive pulp tissue in the apical region. This calls for a forty-eight-hour treatment of the canal dressing. At the next sitting an application of phenolized eugenol and broaching with a fine barbed broach to remove the last vestige of pulp tissue to the accessible foramen is required. Thoroughly bathe the canal with hot water and then dry with paper points as before.

Early Canal Medication.—The medication or dressing should be applied to the extent that the canal has been broached. This dressing should not contain formaldehyde or free phenol or chlorazene as they cause pain. Such mild dressings as eugenol, or camphophenique are popular at this time. We suggest that whatever fluid is used it be made into a paste of bismuth subnitrate with some form of iodine added. Such a dressing will show white in the radiograph, indicating the position of the treatment because of the presence of the bismuth. Over the first dressing, place a hot soft temporary stopping that may be applied and sealed without pressure. Radiograph, and dismiss patient for from four days to one week. If pain develops, redress the canal. If not relieved, make small external drainage over apex of root. Keep cavity opening closed.

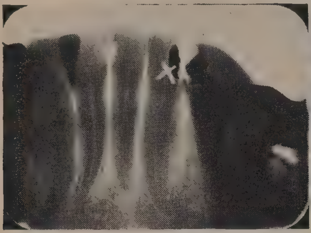


Fig. 350.

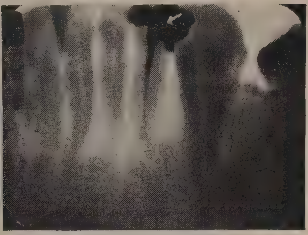


Fig. 351.

Fig. 350.—Clinical Case 424. Simple open putrescence with vital two-thirds. X-ray before treatment.

Fig. 351.—Clinical Case 424. X-ray shows case before operation. Canal dressing of iodinized bismuth paste.

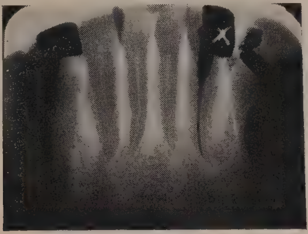


Fig. 352.—Clinical Case 424. X-ray shows canal filled two days after pulp removal. Silver center gutta-percha point set in varnish.

At the Second Treatment.—Place the rubber dam, sterilize the field. Remove temporary stopping. Flood the cavity with camphophenique to wash away the dressing of the first treatments, and then dry with paper points.

During this second treatment in simple putrescence the canal should be broached to the accessible foramen and made accessible for filling by thorough reaming and enlargement with a series of graduated-sized canal reamers and files all with round points. Another canal dressing should be made and radiographed as before, and the patient should be dismissed for one week.

Sudden Shift to Complicated Case.—Quite often cases of simple putrescence, either open or closed, may suddenly develop complications not before manifest. Some operators are tempted to leave these cases open. We regard that as poor practice. It is much better to treat again thoroughly with suitable agents and plenty of water washing, alternated with hot air desiccation. Dress the canal as outlined on page 365, sealing tight with temporary stopping well packed to place, and at once, under local anesthetic, puncture to the apex of tooth through the external plate, and curette the apical space. When such cases develop it is quite probable that complications existed before treatment was attempted, not forgetting the fact that the case may not have been skillfully handled.

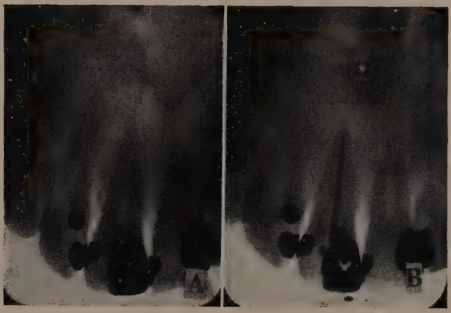


Fig. 353.—Clinical Case 170. Simple putrescence. *A.* X-ray before treatment. *B.* X-ray, first treatment.

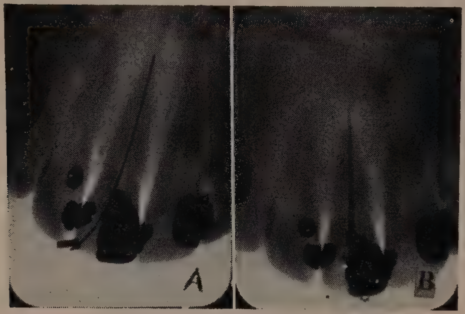


Fig. 354.—Clinical Case 170. *A.* X-ray of sounding for length. *B.* X-ray of sizing canal point.

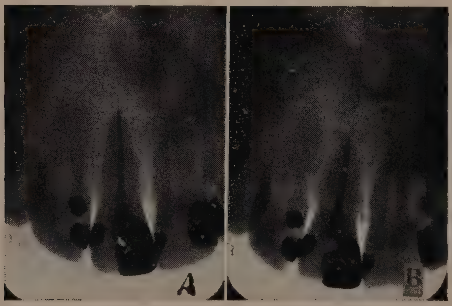


Fig. 355.—Clinical Case 170. *A.* X-ray showing canal filled. *B.* X-ray showing case nine years after canal filling.

Last Treatment.—If uncertainty exists as to sterility or if the case is being used for teaching purposes in college work, upon the return of the patient at the next or subsequent visits, the canal may be dressed for twenty-four hours with a sterile paper canal point saturated with agar gelatin medium and cultured on surface platings or stab plantings made from curettements within the apical foramen. If this is deemed not necessary and there seem to be no complications, the canal is filled and radiographed. Figs. 350 to 352 show such a case so treated.

Simple Closed Putrescence.—A case of simple closed putrescence, that is, a closed putrescence wherein the subdental tissues are not involved, is certainly rare. It does not remain long as an uncomplicated case.

We do find, however, decomposed pulps wherein we can see no previous break in the continuity of the crown and where radiographic and clinical findings do not disclose pericemental lesions. Such canals are generally of long standing and are infected with anaerobic bacteria producing gangrene. They are pathogenic, however, and generally produce a gas gangrene which speedily brings on complications.

Symptoms of Closed Putrescence.—In closed putrescence without complications when presented for treatment, there generally remains a portion of the pulp in the apical region yet vital.

The chief pathognomonic symptom is that heat produces paroxysms of pain while cold fluids in the mouth bring relief.

The treatment for closed putrescence is to apply the rubber dam, sterilize the field, and, with a small bibevel drill, open directly to the pulp chamber, when temporary relief will be immediate. The opening should then be enlarged, the necrotic pulp tissue removed, and treatment proceeded with as outlined for open putrescence.

Canal Filling Following Simple Putrescence.—It is presumed that the rubber dam is in place and that the canal has been entirely vacated. The objective point is the accessible foramen. In case this foramen is large, care should be taken that the gutta-percha point does not protrude beyond.

Technic.—Measure and fit a canal point to just short of the foramen, which approximately closes the lumen of the canal for its entire length and protrudes a short distance into the pulp chamber. Place the canal point in 70 per cent alcohol or spirits of chloroform till needed. In case of a large canal, use a gutta-percha point. When the canal is small and there is danger of its bending before reaching the end of the canal, use a gutta-percha point having a silver center. (See Fig. 352.) Occasionally a lead point is to be preferred, if apicoectomy is liable to follow. Flood the canal with the varnish. This is best accomplished by taking up a quantity of the varnish between the beaks of the pliers and depositing it in the pulp chamber. With a smooth broach, canal plugger, or explorer, either of which should be somewhat smaller than the canal, pump the varnish to the extreme end of the canal, and immediately pass the previously fitted canal point to near the foramen and allow the gutta-percha point to stand two or five minutes—the longer time for the larger points. This gives the varnish time to act upon the gutta-percha point. Proceed to pump the canal point back and forth, using about one-millimeter strokes, and at the last giving slight pressure where large foramen exists, and heavy pressure and solid packing where there is a small foramen which has not been broached. When the canal filling is finished, remove all material from the pulp chamber and cavity to slightly below the cervix. Be sure cavity walls are scraped clean, and then repeat the ammoniated hydrogen peroxide bleaching treatment. Cover walls in anterior teeth with a layer of white cement. In canal filling following putrescence, it is less of an error to protrude a canal point than to stop short of the foramen. (Fig. 352.)

Radiograph repeatedly during this sitting to prove position of measurements and canal filling. The ideal is reached if the varnish appears to be a fraction of a millimeter beyond the mouth of the foramen as all tapering roots are longer than they appear in the radiograph, as the amount of cementum is so small that the differentiation fades out. This is particularly true as patients advance in years, due to increased density of the bone and addition of cementum. (See Figs. 353 to 355 inclusive.)

Fig. 356.

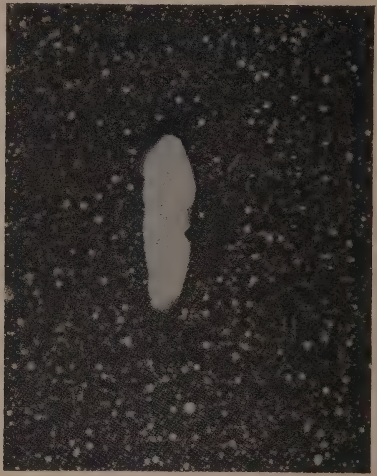


Fig. 357.

Fig. 356.—This tooth was opened to the canal via the foramen, the canal vacated and filled with a known and proved antiseptic, and the apex sealed with wax.

The side of the root was ground past the granular layer of Tomes. This was planted on a Petri dish smeared with a generous planing of *Staphylococcus aureus* and then cultured for several days.

Note there is an abundant growth of the microorganism except where the granular layer of Tomes had been removed.

Fig. 357.—The granular layer of Tomes in this case was removed to the dentine at only a small point and the result was similar to that in the previous experiment, showing that the contents of the canal had made exit only at that point.

Figs. 356 and 357 show the resistance of the granular layer of Tomes. This answers the question why no granulomata form on the sides of the root of a partially dead pulp but appear only opposite foramina. This also clinches the argument that with all foramina sealed it makes no difference about the canal as long as the granular layer of Tomes is intact.

It is quite possible to open on the labial to the apex of a tooth, mechanically enlarge the foramen, plug solid for a short distance, and all pathologic evidence will disappear in the periodontium.

In the biologic laboratory we have trouble staining either way through the granular layer of Tomes except slowly with nitrate of silver and bichloride of mercury.

The idea that a medicated canal filling is of any effect after the foramina have been sealed, is erroneous.

Dr. G. V. Black used one of his lower molars with an adjusted removable gold crown as a culture oven without involving the surrounding subdental tissues.

CHAPTER XLII

PULP PUTRESCENCE, COMPLICATED, ACUTE, WITH AND WITHOUT FISTULA

The acute form of complicated putrescence is generally of early diagnosis because the tooth is generally painful to percussion. In extensive cases one or more of the adjacent teeth also may be sore to tapping. In other cases where the inflammation is very limited, or the apical space large, pain may not be induced by percussion. In these cases there is the very delicate test known as the "percussion note." By alternately tapping the neighboring teeth with normal periodontal membranes and the suspected tooth, it will be noticed that the tooth with the inflamed periodontal membrane will give off a note much lower in the scale.

There will sometimes be the difference of a full octave in the sound. This is known as the "dull percussion note."

The percussion test is best applied by tapping on the occlusal surface or incisal edge of the suspected tooth with the handle end of a steel instrument. These tests, however, are not necessary in most acute cases, since there will have developed sufficient soreness to have been noticed by the patient when closing the teeth.

There will probably be pain or swelling, or both, in adjacent parts, varying from slight discomfiture and little swelling to great disfigurement and extreme agony. The patient is seeking relief for the pain, and that is to be considered at the first visit.

In mild cases of acute complicated putrescence the tooth may be extracted at the first visit, or, if the patient chooses to have the tooth treated, the treatment may be proceeded with at once, the technic being as follows:

Radiograph in one or more angles as the first of the series. Spray or rinse the entire mouth with a suitable antiseptic. Apply the rubber dam. Bathe the exposed teeth with ammoniated hydrogen peroxide. Swab with tap water. Remove filling, if present, and all decay from the tooth cavity and again bathe with suitable antiseptic. Remove enough of the tooth to the occlusal or incisal surface to give direct access to the canal or canals. If the pericementum is only inflamed and the presence of pus is not probable or detectable, the treatment is the same as that outlined for simple putrescence with the addition of external applications to the gum over the affected tooth to stimulate resolution. Painting with aconite and iodine is suggested after removing the rubber dam.

After gaining complete access to the canals and flooding the cavity with camphophenique, work through this flood with suitable-sized canal reamers always revolving clockwise, removing the canal contents of the occlusal and middle thirds. In some mild cases of easy access it may be permissible or wise to broach three-fourths or four-fifths of the way up the canal at the first sitting, working all the while through a puddle of camphophenique. In this way, whenever the broach is removed this valuable antiseptic takes its place, thus medicating as deeply in each case as the canal has been broached.

When that portion of the canal has been broached, proceed to dry the canal by the use of paper points and hot air from the blower. Never wrap a broach with cotton with the fingers and place it in a pulp canal. Dentists who have used that and similar methods no longer believe in pulp canal therapy and have turned ''hundred percenters.'' Do not handle the paper points with the fingers. At this point you may use any treatment you choose. However, may we caution against the use of formaldehyde in any combination or chlorazene, as either is most frequently followed by pain and sore teeth even after the canal filling. These conditions are nearly always absent in cases where the iodinized bismuth dressing has been used. We will proceed with the technic of its use in these mild cases of acute complicated putrescence.

Technic.—With the tooth cavity and the canal dried and desiccated with hot air to the point of the patient's tolerance, a quantity of the canal dressing about the size of a grain of wheat is carried on a spoon excavator to the cavity. This is then moistened with a drop of camphophenique from the beaks of fine pliers, thereby making a paste which should be carefully worked into the canal to the extent that it has been previously rendered vacant. The proper consistency of this created paste is to be as thick as it may be and leave no hole unfilled in the canal when a smooth broach is immersed and withdrawn. The use of a suitable-sized canal reamer turned reverse of clockwise will assist in placing the paste to the depth the canal has been vacated. Next, with suitable spoon excavators, clean out all of the paste from the chamber, even scraping the cavity walls clean. Fill the cavity with hot soft temporary stopping gently wiped to place so as to create no pressure on the contents of the canal, which, if done otherwise, may result in pain to the patient.

The paste should contain thyme and eugenol, both local anodynes. We advise against the use of pure phenol, as the coagulation of the albumin so lessens the extent of penetration of other substances used in the treatment that sterilization of the dentine beyond is next to impossible.

Remove the rubber dam and x-ray as the second of your series marked ''first treatment.'' In taking all x-rays, much care should be given to get shadows that are the same length as the tooth being treated, and this second picture in the case must be right as we need its length as a guide.

Dismiss the patient for one week. If pain results, repeat before that time. Such cases are not often met with.

Second Visit.—Sterilize the field. Place the rubber dam. Again sterilize exposed teeth. Remove temporary stopping. Flood cavity with two or three drops of camphophenique. Working through this puddle of camphophenique, remove previously applied paste as well as the remains of the last apical third of the canal, renewing the quantity of camphophenique and finally wiping out and completely vacating the canals, best accomplished with a set of assorted twist broaches or reamers. Use by turning clockwise. Again dry and heat and apply paste, and x-ray as the third of our series. This x-ray should show the bismuth paste to the mouth of the accessible foramen. Dismiss the patient this time for a week or ten days when he may return for a permanent canal filling, or the case may be carried through more treatments if it seems to demand them.

In severe cases of active complicated putrescence without fistula the technic is more varied and we have what requires the best of judgment. These are the cases the beginners most dread and are the most liable to after-medication pains. When pus has formed and, upon broaching, is freely evacuated down the pulp canal and the patient experiences relief, it is sometimes best surgery, where the flow is copious, to allow free drainage by this route for twenty-four to forty-eight hours before attempting further treatment. At the end of this time the most active symptoms will generally have subsided and the case can be proceeded with much the same way as with mild cases, just given in detail, except that there should be more treatments with longer periods between each treatment after the second treatment. In case much infection has gone beyond the foramen into the surrounding tissue, pain and pericementitis may persist. In such cases an opening should be made externally over the apex of the root, creating a fistula surgically, and the case should be treated as acute, complicated, with fistula.

In acute complicated putrescence where a surgical opening has been made, immediately force the bismuth paste made thin with camphophenique through the canal and out of the newly made drainage.

Technic.—To anesthetize use block, general anesthetic, or local obtundents, but do not inject the immediate tissues. Make a small opening labially into the mucoperiosteum and pass a No. 6 round bur to the apex of the tooth. With a No. 20 spoon excavator make sure that the apex has been reached. Then place the rubber dam and proceed as previously outlined in the milder cases, except that when the canal has been pumped full of the dressing made rather liquid, a small quantity is allowed to remain in the pulp chamber and the warm temporary stopping is packed into the cavity with considerable pressure as it cools, which will force much of the dressing out into the subdental space and surgical tract.

Radiograph as a part of the series and dismiss the patient for about a week. When the patient returns, first see that surgical opening is still free to the apical foramen. Radiograph for the series and note the absorption of the treatment paste. Place rubber dam. Flood cavity and canal with camphophenique and remove all the dressing. Again pump new dressing through the foramen. Then proceed to remove all of the new dressing from the canal and dry, preparatory to filling the pulp canals with varnish and a gutta-percha point. The putting of this paste through the apical foramen clogs any back seepage, and a perfectly dry foramen and canal may be obtained.

With these cases where a surgical external drainage has been made, the author prefers to fill the canal permanently at the next sitting. This having been done, the rubber dam is removed before putting in the temporary stopping. The case is radiographed. In case the canal filling does not reach the apex, additional pressure and tamping may improve the condition. In case the canal point protrudes very much, a No. 20 spoon may be passed through

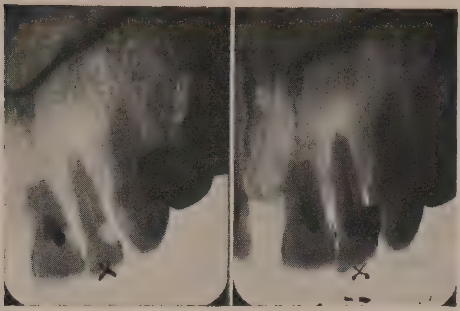


Fig. 358.—Clinical Case 335. Complicated active putrescence without fistula *A*. X-ray before treatment. *B*. X-ray, first treatment.

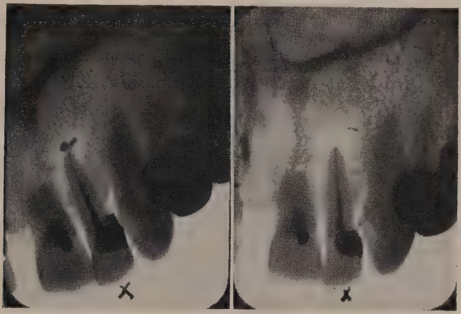


Fig. 359.—Clinical Case 335. *A*. X-ray, second treatment. *B*. X-ray of filled canal.

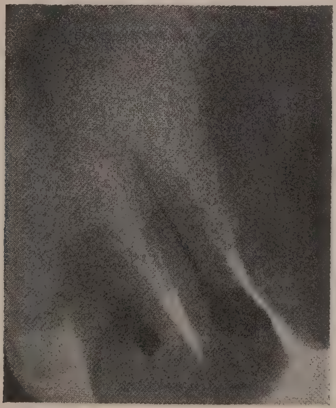


Fig. 360.—Clinical Case 335. X-ray three years after treatment and canal filling. A section of a broken off gutta-percha canal filling does not seem to even irritate the tissues. Evidently the foramen is plugged tight. Note the adjacent central incisor where a partial pulpectomy was done more than twenty-five years previous to taking this picture. This same dentist has turned to oral surgery, and condemns all pulpless teeth.

the surgical opening to the apical foramen and the excess curetted out. This operation may be done safely with a local infiltration as the infection has been removed. (See Figs. 358, 359, and 360.)

Acute Complicated Putrescence With Fistula.—This is a case where the fistulous tract has recently been established and the active symptoms of infection are present and treated as follows:

When these cases present, the entire sterilizing process and treatment should extend from tooth cavity to fistulous opening at the first sitting. Mechanically and chemically remove all the contents of the canal and render as surgically clean as possible. Then wash out the entire tract with mild antiseptics, such as camphophenique, cassia water (Dr. Black), normal salt solution with 5 per cent phenol added, or a saturated solution of borax. Use plenty of some of these mild solutions. No irritating or caustic drugs are indicated in the newly established tracts. Fill the canal to the apex with the dressing. Radiograph, and dismiss the patient for one week.

Second Sitting.—Force paste through foramen or foramina out into the fistulous tract.

In case one has not been able to broach root to apex or to all foramina, these may be reached by forcing paste to the farthest points with a plug of unvulcanized rubber at the second or third sitting.

In a large percentage of the cases the only denuded cementum is within the flaring mouth of the foramen. The most ideal results in such cases are obtained when this enlarged mouth shows an enlargement in the canal filling at the foramen.

In complicated putrescence, acute or chronic, without fistula, it is best to have varnish exude from the foramen just enough to coat the margins of the foramen with the gutta-percha point, stopping short of the outer edge of the foramen.

Technic.—The technic is the same as that for filling the canal for noncomplicated cases except that the filling should be placed at least flush with the mouth of the foramen.

In closing this chapter we wish to emphasize the importance of knowing the length of all canals or the depth to which they have been penetrated, and of having these depths marked by litle rubber disks, one for each branch entering the canal after the depth has been obtained. Also measure all gutta-percha points as to length and size before using. Full details of canal filling for each of the various conditions are given in Chapter XLVI.

CHAPTER XLIII

PULP PUTRESCENCE, COMPLICATED, CHRONIC, WITH AND WITHOUT FISTULA

The diagnosis, treatment, and prognosis of chronic, complicated putrescence are entirely different from those of simple, acute, and active cases of recent origin.

This condition is found in every degree of severity from the slightest affection and infection on through the various degrees of tissue destruction to include the loss of large areas of bone and soft tissue.

Sequelae.—As the sequelae of these conditions, there may be found systemic involvements more varied than the local indications and not always in the same ratio as to the degree of severity. Even the slightest degree of apical infection may be accompanied by the most pronounced expression of absorption. This feature of adverse ratio sometimes observed is best understood by a study of body resistance, one of the very important factors to be considered in the management of apical infections.

The steps in diagnosing chronic infections about the apices of teeth are:

First, note the objective conditions of the tooth, pulp canals, and surrounding parts.

Second, secure as complete a history as possible of the case and of the dentistry done on that individual tooth.

Third, have a defining radiograph of the tooth and surrounding parts made.

Fourth, a blood examination should be made in ailing patients to detect the absorption of infection, which is shown by a leucocytosis or even a leucocytopenia. A differential count should be made to determine the poliomorphonuclear leucocyte and eosinophile percentages.

The examination of the blood stream will not answer the question as to whether or not the individual tooth being considered is responsible for the apparent absorption of infection, but will assist in checking up existing general conditions, the relative resistance of the patient, and the final results of the treatment which may be expected.

Radiographic Indications.—The radiograph is valuable only as a link in the chain of evidence. Small pulp canals in the roots of teeth, filled or unfilled, do not show in the radiograph. Large canals may show as having been filled to their several foramina, and yet each and every canal may be but partially filled. There may be existing spaces about the canal filling.

Destruction of large areas of bone about the apices of a tooth are generally shadowed on the radiograph. But there may exist an extensive rarefying osteitis, where bone destruction is only partial and with no evidence being recorded in the radiograph. The presence or absence of the lamina dura about the apex of a tooth, relied upon by many, may be misleading, but, when shown in the radiograph, it is that much more evidence that the structures at least approximate health. It may be present in its most perfect form, and yet to shadow the condition on the radiograph may be an impossibility.

The fine dark line with the defined white line about the root of a tooth, shown in the negative, is possible of depiction only when the travel of the rays parallel for some considerable distance the surface of a root which is flat and wide. This portrayal is not possible when radiographing a small root end, or a very pointed root, or a root end or surface that describes the arc of a small circle.

These last conditions result in a blended gray which will make the case appear as though there had been an entire obliteration of the apical space and the trabeculae extending to the cementum of the tooth.

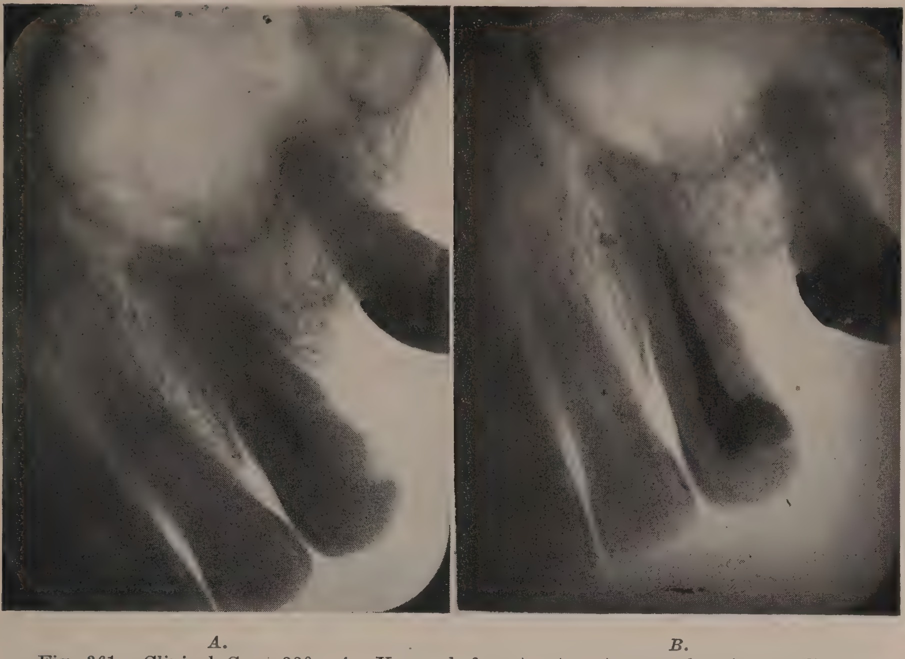
The radiograph will show only gross anatomy and general relations and conditions of the structures, and will to that extent assist in the preliminary steps in the diagnosis. It will also assist in checking up the gross changes resulting from subsequent treatment or surgery. The radiograph will not show the internal anatomy of the root ends of teeth. This is a study which must be left to the microscope in the laboratory.

The treatment of complicated chronic putrescence is as varied as the symptoms presented and the conditions found. The first order of procedure is the removal of the cause, which includes the elimination of the putrescent condition within the pulp canal under aseptic precautions.

Chronic Complicated Putrescence.—Pulp canals without fistula as a rule give the least local symptoms, but are responsible for the most damage to the general health.

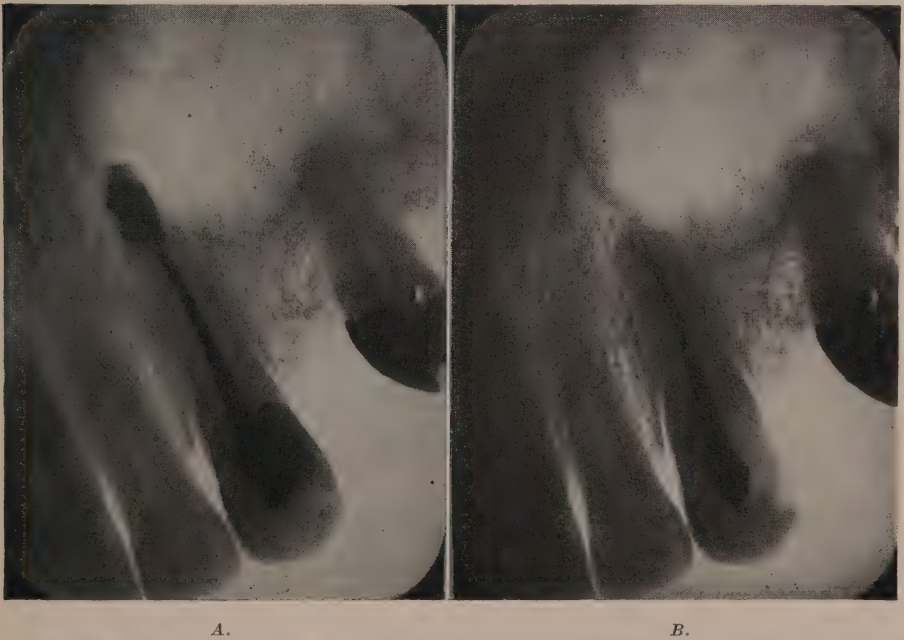
Many forms of general diseases have been attributed to root infection, as previously discussed, the evidence being quite conclusive. At this time it would seem as though, in cases wherein a granuloma had formed, treatment for the removal of the infected condition should be advised for most teeth, provided the case is suitable for an apicoectomy. This may be necessary for any putrescent case attempted soon after the completion of the canal filling. It would therefore follow with putrescent teeth that all upper molars and the second and third lower molars should be attempted with caution. Sometimes the first lower molar does not prove difficult provided denuded cementum does not exist. Many lower bicuspids may be treated for putrescence, but we do not advocate apicoectomy in these teeth on account of their close proximity to the mental foramen. A tooth is not worth a permanently desensitized or paralyzed lower lip, which is liable to result from apicoectomy on lower bicuspids.

Granuloma.—These cases of chronic putrescence without fistula may or may not have a granuloma attached to the root end. Its presence or absence bears no relation to the presence or absence or the amount of infection at the time of consideration. A granuloma is the remains of an active defense on the part of the individual, and those which are of the longest standing and are the best defined by the x-ray are the most likely to be sterile, and express a high defense on the part of the host. In case that defense is lost, the circumscribed area may become diffused and its definition less marked or perhaps lost altogether by a materially enlarged granulation, which in time may be



A. *B.*

Fig. 361.—Clinical Case 320. *A.* X-ray, before treatment as a chronic complicated putrescence without fistula. History: case had been treated some ten years previously and the canal stuffed full of a string of cotton saturated with a well-advertised "pulp preserving paste." The author preserved the cotton string. Note the area superimposed on the sinus wall. *B.* X-ray shows first treatment in place.



A. *B.*

Fig. 362.—Clinical Case 320. *A.* X-ray shows third treatment with iodinized bismuth paste forced into the granulation tissue. *B.* X-ray shows case a week later and answers the question, "What becomes of iodine and bismuth?"

only Nature's way of increasing the bulk and power of that defensive mechanism. This defensive membrane is misnamed, however, as it is not a neoplasm. Remove infection, and its processes and this defensive membrane will be removed and replaced with tissue normal to the part occupied by the granulation. (Figs. 361 to 364 inclusive.)

Sterile objects such as the end of a sterile canal point will be incapsulated by a thin membrane only.

Radiographic diagnosis had best be made carefully. The root should be radiographed from three positions: direct, 15 degrees mesial, and 15 degrees distal, from the direct. Each step in the treatment should be radiographed and the series continued at monthly and, finally, yearly intervals till its condition becomes stationary and no longer convertible.*

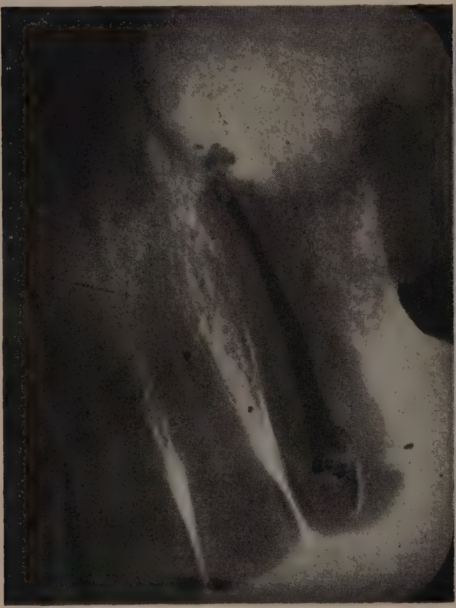


Fig. 363.

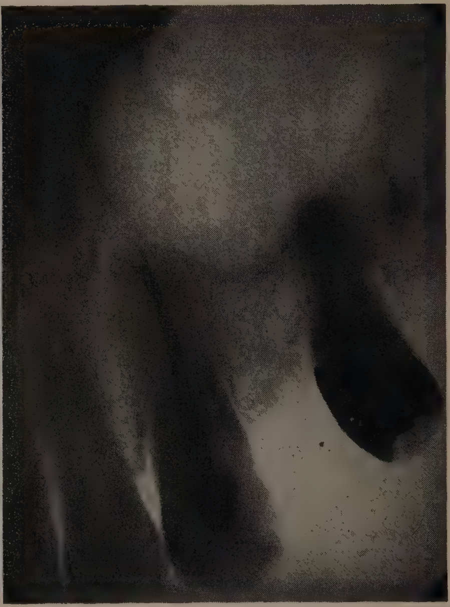


Fig. 364.

Fig. 363.—Clinical Case 320. X-ray shows canal filled after a small treatment had been forced past the foramina.

Fig. 364.—Clinical Case 320. X-ray shows same case eleven months later on the day the tooth was extracted for laboratory examination and sacrificed for the good of research. Note the granulation area has been filled with bone and the process of recovering the tooth apex is well under way. The tooth was surgically removed by the process usual in such cases, sent to the Pathological Laboratory of Dr. Miles J. Breuer where the tooth root was macerated and cultured for six days. The bacterial report was as follows: Culture on semisolid brain-heart-blood infusion agar, no growth to date. On this medium the growth of streptococci is so prompt and abundant that I am confident after this length of time that no further growth is to be expected.

Technic.—The technic of the first treatment for a case of chronic complicated putrescence without fistula is in every way like that outlined for simple open putrescence in Chapter XLII.

Second Treatment.—At the second or third visit a passageway from the canal to the apical pathology in chronic complicated cases must be found or made. This area must be reached and medicated. The rubber dam has been placed, the field sterilized, the previous dressing removed, and a new application of the bismuth paste made as described in the previous chapter. This dressing is introduced with a twist canal broach turned reverse of clockwise, to fill the entire canal. If the accessible foramen is large, a sufficient amount may have been worked beyond the foramen. (See Fig 362, *A*.) If the foramen is small, however, hot temporary stopping should be wiped into the cavity, and when partially cooled, using amalgam instruments, it should be crowded into the cavity to act as a piston to force some of the treatment beyond the apex. Fig. 362, *B* shows the same case a week later. The treatment has been absorbed.

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*As this volume goes to press, the author has 565 x-ray series of such cases being periodically checked.

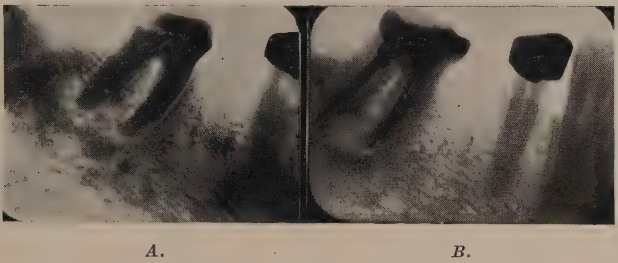

Fig. 365.—Clinical Case 298. Chronic active complicated putrescence with fistula. *A*. X-ray before treatment. *B*. X-ray after treatment at 15 degree angle.

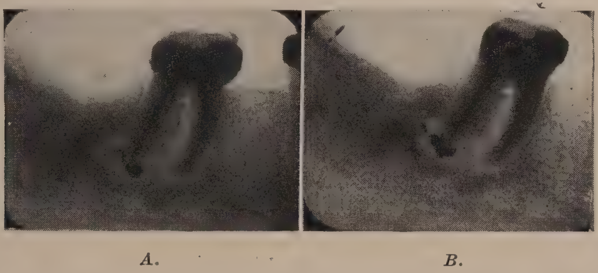

Fig. 366.—Clinical Case 298. *A*. X-ray, second treatment. Iodinized bismuth paste was forced the entire length of fistulous tract. *B*. X-ray, third treatment. Tract closed.

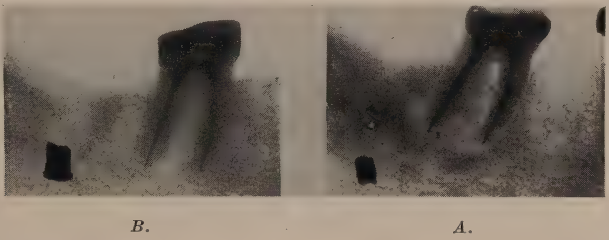

Fig. 367.—Clinical Case 298. *A*. X-ray shows canals filled. *B*. X-ray, six years after treatment and the filling of the canals with gutta-percha and varnish.

Other treatments should follow this till there is evidence radiographically of bone repair. In case there is a flare up, as to pain and local swelling, secure immediate drainage by opening to the apical region through labial plate, and curette the entire granulation area with a sharp No. 20 spoon excavator or other small curette. The case then goes over to the next division, i.e., that with fistula.

Chronic Fistula.—When a chronic case with fistula is at hand for treatment, the first treatment should be clear through from tooth cavity to the opening of the gum. First, radiograph. Second, sterilize the field. Third, excavate and enlarge cavity to a direct vision of the canal. Fourth, thoroughly sterilize the pulp canal, then the fistulous tract. The tract should be established by forcing hamamelis or cassia water through the pulp canal and out through the sinus. Follow this with phenol or aconite and iodine only sufficient to cauterize the entire surface of the tract, thus destroying the fibrous lining usual to such tracts when of long standing.

With fistula acute or chronic the canal filling should be placed before the fistulous tract or surgical drainage has been closed, flush with the end of the root, as in nonfistulous cases. If there still exist lateral branches to other foramina or if the external surface of the cementum is denuded, hence dead, such cases may not show recovery and may sometimes require the operation of apicoectomy, treated of in a subsequent chapter. (See Figs. 365, 366, and 367.)

Prognosis.—Recovery of all divisions of chronic complicated putrescence is generally rapid except where there exist unsterilized lateral branches to their several foramina, or denuded, and hence dead, cementum. Such cases may require apicoectomy, the operation of which is described in Chapter XLVII.

Drugs and technic used frequently in the management of more or less serious cases of pulp canal putrescence, including complications:

1. Ammoniated silver nitrate.
2. Bismuth subnitrate.
3. Bone wax.
4. Camphophenique (powder and liquid).
5. Heated probes or broaches.
6. Iodine.
7. Oil of cloves.
8. Procaine.
9. Spirits of chloroform.
10. Heated water.
11. Heated air.
12. Varnish and gutta-percha points, silver centered for small canals.
13. Hexyl-Resorcinol Solution S.T.37 for canal dressing.
14. Reamers for mechanical cleansing.
15. Sulfanilamide.

We object to all medicines that would injure the mucous membrane of the mouth as they will produce periodontitis if applied to a tooth without complications.

The ammoniated silver nitrate is for the apical region only. The bismuth is to show the position in the x-ray. The bone wax is for closing perforated roots. The spirits of chloroform is to assist in pulp canal filling. No caustics are used.

The heated water is all that is really needed for treatment. (See ''Drugless Management,'' Chapter XLIV.)

CHAPTER XLIV

THE DRUGLESS MANAGEMENT OF PUTRESCENT PULP CANALS

Too much dependence is placed on strong drugs and caustics and too little on mechanical cleansing of the canals assisted by a lowering or raising of the temperature beyond the tolerance of the bacteria involved.

In complicated putrescence, either acute or chronic, endodontists have noted in their series of x-rays that the area about the foramina of teeth has progressively enlarged. This, we believe, is due to the use of caustic drugs.

When the treatment has been limited to the use of twist broaches, heated air and water, or even those remedies which one would not hesitate to use as a mouthwash, the area begins to gray, showing that calculus is being deposited.

The hot water treatment is particularly applicable to chronic cases with fistulous openings as the clear hot water can be sprayed through with a syringe and need contain no drug.

When, however, there is no external opening and the operator does not choose to make one, the case may well be handled without the use of drugs.

The dentist should be equipped with electrically heated probes of suitable sizes connected with the unit.

Technic.—The rubber dam is in place, of course, and the canal is reamed out with a Kerr reamer, smallest size, No. 1, followed by the next size and the next as long as the reamers will follow the canal.

The canal is then washed clean of debris and dried with a hot-air syringe with low pressure. The canal is then filled with boiled water and the heating probe passed to near the apex with the current turned on. Heat to the toleration of the patient three times, and dry. After a single sitting, the canal is ready for the filling.

This drugless treatment has to recommend it, the fact that it is a time saver, the teeth are not discolored by drugs, and the number of sore teeth and swollen faces is materially lessened.

Streptococcus viridans, the most frequently found bacterium, is also found in ulcers of the endocardium; fortunately, it is not hemolytic. In case colonies get into the blood stream they drift or roll along the arteries till the caliber becomes too small to accommodate that size object and a thrombosis results.

As these floating collections are very minute, only the smallest of the arteries are clogged, such as those in the heart valves, the retina of the eye, and the nerve centers.

The theories of selectivity as advanced by some writers years ago are no longer accepted by most bacteriologists. This would eliminate *Str. viridans* as the cause of many human ills previously attributed to the presence of this bacterium about human teeth.

Other bacteria which have been allowed to cause contamination from the flora of the mouth are of much greater importance in complicated cases than the *Str. viridans.* The viridans is an anaerobe, and exposed to the air of the room is readily oxidized or burned up. The viridans has been grown within the temperature ranges of the body and radical change of temperature results in sterilization.

Sterilization in the use of hot water, hot air, and the heated oven is of most universal use in the home and it can be and is used with success in the handling of infected pulp canals by the endodontist.

Christian Science patients need not have drugs used in the cleansing of the canals as hot water is entirely effective. The dentist himself, if a Christian Scientist, may discard all drugs commonly used in practice and have as speedy and thorough results as his more liberal colleague. The author, who is not a Christian Scientist, has proved this with his patients.

Dr. Harry Albert of New York, who was for eighteen or more years instructor and head of the department of canal surgery and therapeutics in the New York Dental College, has an experience of several thousand cases. The following is a quotation from Dr. Albert:*

> ''Preservation of teeth with involved pulps makes imperative a procedure of proven value, based on valid, established surgical principles. The fundamental requirements in such a procedure would have to be based on a recognition of the nature of the tissues dealt with and the results desired. Since the normal variations of canals and accessory canals, with their respective foramina, offer insurmountable difficulties, a *modus operandi* also should include a consideration of the reparative forces at the apical and periapical regions. Any violation puts an added burden on the normal repair processes, and needless weakening or destruction of the periapical tissues results in a reparative delay, or due to lowered resistance, may invite bacterial invasion with subsequent added destruction and further necessity for repair.
>
> ''Pulp canal surgery in itself is not difficult to master if all factors involved are taken into consideration. Detailed study and treatment planning will permit for greater success. A process of reasoning will go far in developing the individual techniques of the operator and in indicating those modifications in a rational procedure as are deemed necessary.
>
> ''Greater benefit would be accorded the patient, and the embarrassment inherent in failure would be overcome if caution were exercised in carefully predetermining the ultimate goal; it serves ill to go the wrong way in a hurry. Success depends on correct diagnosis, rational technique, surgical asepsis, control of surgical and chemical trauma, and sealing of apical foramina.
>
> ''The fundamental objective remains the retention of the involved tooth in the dental arch in a state of good health. Only if such retention is indicated as the resultant of a sincere deliberation of the many influences affecting the situation, should pulp canal surgery be undertaken. Further, only if the final outcome of the procedure results in a non-pathological unit should the tooth be retained.
>
> ''The general practitioner, therefore, should have a thorough knowledge of such concepts, if he is to render a *complete dental health service* to his patients. The tendency of eminent authorities to obscure the issues involved, by their diverse opinions, has led to much confusion in this field. It is in recognition of the great need for a simplified, practical and rational method of pulp canal therapy and surgery, that this article is presented.
>
> ### RECORD OF THE TREATMENT
>
> ''Many efforts have been made in the past to evolve a record form applicable to the needs of pulp canal surgery. The chart shown in *Figure 1* [Fig. 368] now has been employed

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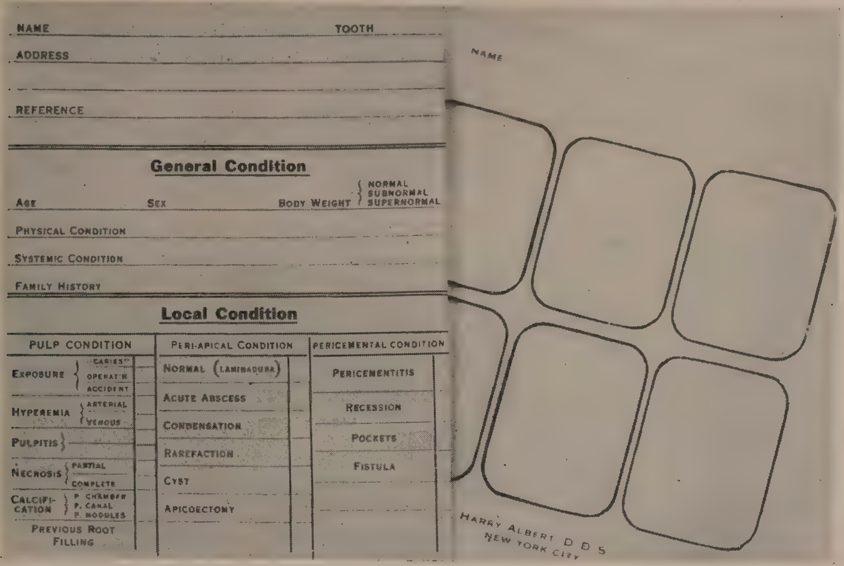
*Albert, Harry: Pulpodontia: Pulp Canal Therapy and Pulp Canal Surgery, Dental Outlook 28: 3, 1941.

for some years and has proven most satisfactory. It will be noted that significant factors can be indicated easily for both general and local conditions. This is printed on one side of an envelope, the opposite face of which allows for a running statement of the progress of the treatment. The envelope proper is utilized for the mounts of the case roentgenograms.



NAME TOOTH

ADDRESS

REFERENCE

General Condition

AGE SEX BODY WEIGHT { NORMAL SUBNORMAL SUPERNORMAL

PHYSICAL CONDITION

SYSTEMIC CONDITION

FAMILY HISTORY

Local Condition

PULP CONDITION	PERI-APICAL CONDITION	PERICEMENTAL CONDITION
EXPOSURE { CARIES OPERAT'N ACCIDENT	NORMAL (LAMINADURA)	PERICEMENTITIS
HYPEREMIA { ARTERIAL VENOUS	ACUTE ABSCESS	RECESSION
PULPITIS }	CONDENSATION	POCKETS
NECROSIS { PARTIAL COMPLETE	RAREFACTION	FISTULA
CALCIFICATION { P. CHAMBER P. CANAL P. NODULES	CYST	
PREVIOUS ROOT FILLING	APICOECTOMY	

NAME

HARRY ALBERT D D S
NEW YORK CITY

Fig. 368.

Figs. 368 to 375 from Albert, Dental Outlook, February, 1941.

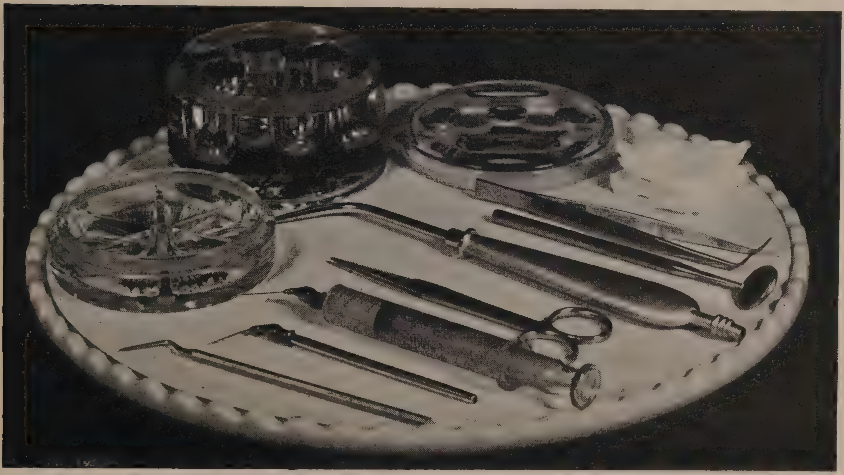


Fig. 369.

SELECTION OF THE ARMAMENTARIUM

"The major portion of the instruments employed for the treatment of a given tooth is selected from a study of the case roentgenogram. A round bur is employed for opening into the pulp chamber and is followed by a tapering fissure bur to provide more direct access to the pulp canal. The size of the canal determines the suitable barbed broach for extirpation of the pulp. The files to be employed in the preparation of the canal are selected similarly on the basis of the size and configuration of the canal. In addition, the size of the canal also indicates the selection of the gutta percha points to be used for the filling operation.

"Every effort should be made to prepare the operating tray with the greatest care (*Figure 2*) [Fig. 369]. The basic instruments required include: college pliers, mirror, scissors, aspirating tip, syringe with sterile water, aspirating tip with platinum needle, plugger point, a few sections of sterile gauze, and the indicated burs. A suitable container, divided into sections, accommodates all the pulp canal instruments employed for the average case. The sterilizing unit shown permits for convenient sterilization on the bracket table. The entire preparation of the operating tray is desirable previous to the application of the rubber dam. The selected pulp canal instruments, including burs, a broach, files, gutta percha points, and additional specially indicated materials are distributed among the three smaller wells of the sterilization unit.

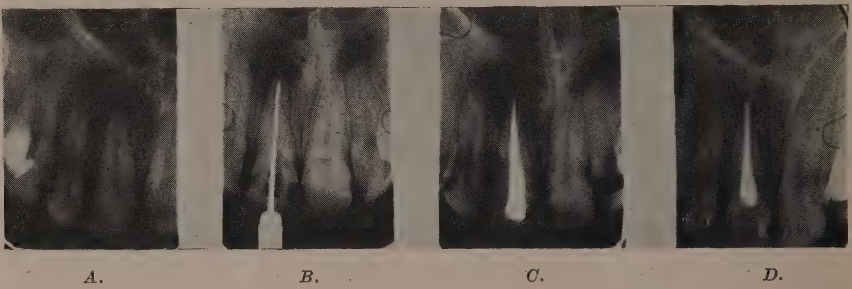


Fig. 370.—Case 1. A 15-year-old girl presented with a nonvital upper central incisor showing an area of periapical destruction (*A*). The measurement control as shown in *P* was taken to ascertain root length. *C* shows the filling inserted, while *D* indicates the periapical healing fourteen months later.

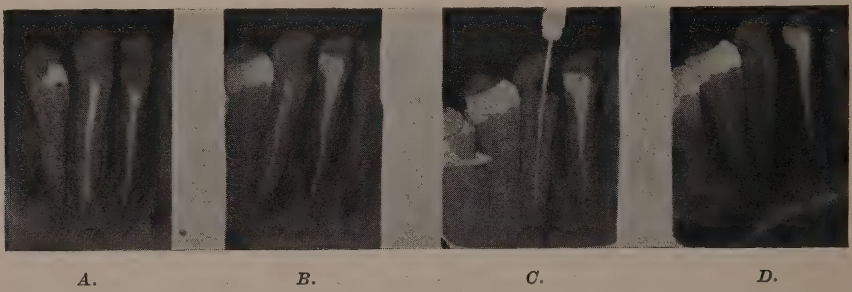


Fig. 371.—Case 2. A 17-year-old girl presented with a nonvital upper cuspid showing an area of periapical destruction, particularly localized on the mesial side of the apex (*A*). *B* indicates the measurement control, while *C* shows the filling inserted and the unusual formation of the canal. The involved area is seen to have healed nineteen months later (*D*).

PROCEDURE IN TREATMENT

"For convenience and access and for an aseptic procedure, the rubber dam is necessary in all cases in which it can be applied. A wide area surrounding the isolated tooth is sterilized by painting with iodine, followed by an alcohol wash.

"The indicated bur is now removed from the germicidal solution by sterile college pliers, washed in the alcohol of the large well of the sterilizing unit, and employed in opening into the pulp chamber for access to the canal or canals. To remove such débris as has been accumulated, lavage with sterile water followed by aspiration is recommended rather than the use of a blast of air. This procedure will be required at intervals throughout the treatment.

“Removal of the pulp canal contents in a vital case, under anesthesia, is effected through the use of the indicated barbed broach. From this point on, an identical procedure in preparation is followed with both vital and non-vital cases. The pulp canal is enlarged by the progressive use of files of increasing size to a point where the walls are smooth and clean, and the canal is of a diameter and configuration to permit for the filling operation. In all instrument manipulation, within the pulp canal proper, effort must be made to avoid passage of the instruments beyond the apical foramen. Laceration and injury of the periapical tissues, or the forced entrance of débris or infected matter from the canal into the periapical region, cannot but act to impair healing.

“The use of medicaments in pulp canal therapy to destroy micro-organisms or inhibit their growth, may lead to untoward effects on the apical and periapical tissues. Respect for the tissues involved by severe limitations of medicaments employed will give the desired results in successful repair. The vital case, subsequent to final lavage, after preparation of the canal with the previously outlined aseptic procedure, needs no medication preceding the filling operation. Such organisms as may be present in the apical region are destroyed effectively by the unimpaired local tissue resistance. The non-vital case is treated by lavage with sterile hot water, in order to cleanse the canal and induce an active hyperemia apically. The action of bacteria further may be overcome by ionization of the canal. Electrolytic medication probably is effective by both direct sterilization, and mild stimulation in increasing the blood flow to the part.

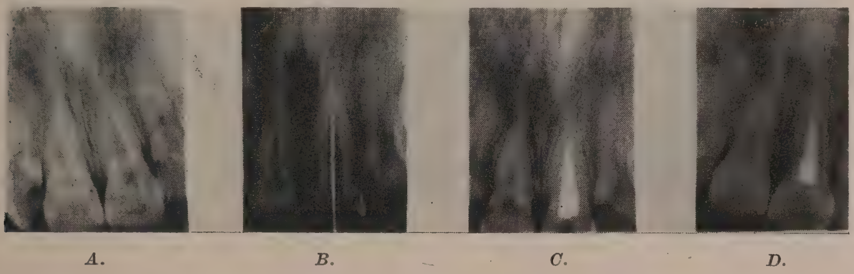


Fig. 372.—Case 3. A 20-year-old girl presented with a nonvital upper central incisor, with no evident periapical involvement (*A*). *B* indicates the measurement control, while *C* shows the filling inserted. It will be noted that the narrowed apical portion of the canal was not enlarged, in order that impairment of seemingly existent repair process be avoided. *D* shows the case five years later.

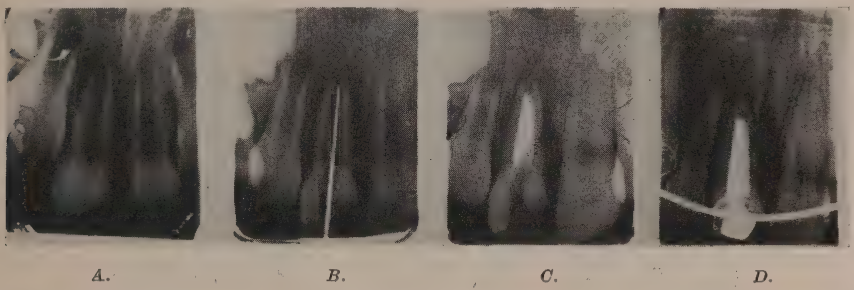


Fig. 373.—Case 4. A 7-year-old boy whose upper left central incisors were fractured, thereby exposing the pulp (*A*). An attempt at pulp capping, and subsequent pericemental inflammation two months later necessitated pulp canal treatment. *B* shows the measurement control and *C* indicates the filling inserted. Because of unimpaired tissue resistance and placement of filling short of the vital apical tissue, it was possible for normal cementoblastic repair of the apex to occur. *D* shows the closed apical foramen five years after the filling of the canal.

“*The filling operation* is of critical importance in the success or failure of a given case. Our objective should be a completely sealed apex with a dense homogeneous gutta-percha mass, filling the canal and closely adherent to the canal walls. A sterile gutta-percha point, of a size previously determined, is modified in such a fashion that the tip when softened with chloroform, will mold itself into the apical foramen. Apical foramina are of varied shapes, usually ovoid. A gutta-percha point of a greater diameter than the narrowest portion of the ovoid, when softened with chloroform and forced into the apex, the sides of the gutta-percha point will tend to flow and take the form of the apical foramen, thus insuring the seal."

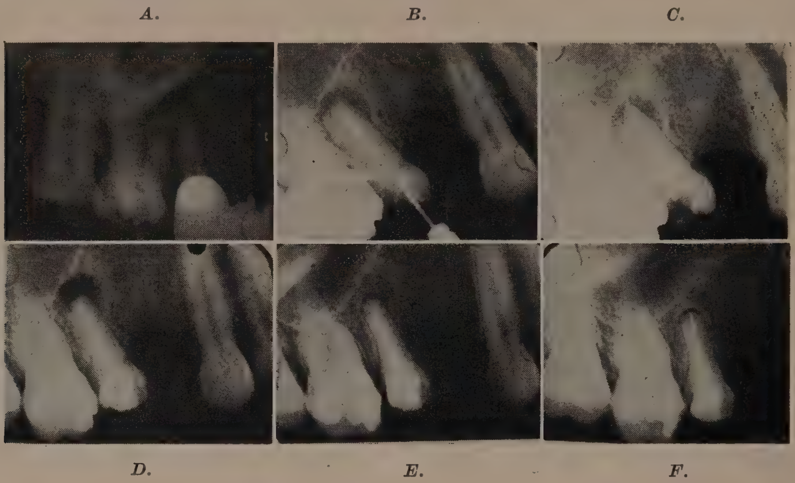


Fig. 374.—Case 5. A young woman, 26 years of age, presented with a nonvital upper second bicuspid, showing a marked apical area of destruction (*A*). *B* indicates the measurement control, and *C* shows the root filling inserted. Apicoectomy was here indicated and the result following operation is shown in *D*. Progressive healing occurred as shown in three months (*E*), and in nine months (*F*).

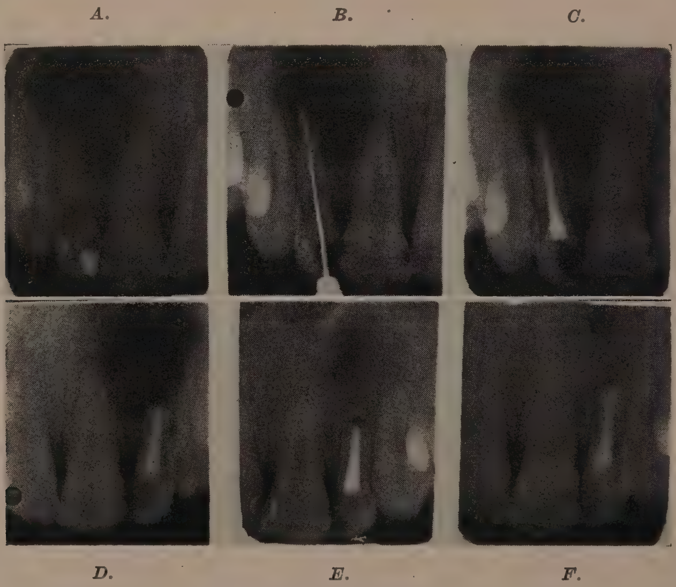


Fig. 375.—Case 6. A 17-year-old girl presented with a nonvital upper lateral incisor showing an area of periapical destruction extending from the cuspid to the central incisor. *A* and *B* indicate the measurement control, and *C* shows the root filling inserted. Apicoectomy was here indicated and the result following operation is shown in *D*. Progressive healing occurred as shown in seven months (*E*), in fourteen months (*F*).

It must be remembered that heated water or air must not be used in cases of pulpectomy or partial pulpectomy as the remaining stumps of the pulp would be burned flesh which Nature would have to remove later. As this is not easily done, it would probably result in the stumps of the pulp becoming putrescent.

Fortunately for this class of cases there is no need of using drugs as they are easily handled with a mild application of subnitrate of bismuth paste to locate the place or places of pulp excision.

In twenty-four hours the sensation will have returned to the pulp to guide us in placing a partial root filling.

Care is then taken not to produce anemia by pressure on the pulp stump.

Using drugs of a caustic nature many times will result in the devitalizing of the remainder of the pulp and will necessitate reopening the case and treating for putrescence.

CHAPTER XLV

CORRECTING PREVIOUS PULP CANAL SURGERY

Selection of Cases.—Renewal of canal fillings should be advised in all cases where the radiographic evidence, clinical findings, or the history of the case point to a defective operation.

Pathology.—When a pathologic condition is shown radiographically about the apical third of a root, the canal of which has been previously but not recently operated on, steps should be taken to eradicate that condition. The canal should be rendered vacant again and sterilized, and a satisfactory canal filling should be placed, which in some cases must be followed by an apicoectomy. If the case fails to show recovery in due time, or if there is any reason why retreatment cannot be attempted, the tooth should be extracted. One should not forget, however, that the sight of any dentistry in a tooth and particularly in or about the pulp cavity encourages some people to have visions, and they see much pathology about that tooth when the same conditions about a tooth which has never had any dentistry are passed by as not being involved. At this time Dr. Clarence O. Simpson of St. Louis, one of the leading radiodontists of America, is giving much attention in an endeavor to teach us not to see what we think we see, and to give the dental and medical profession a clearer vision of subdental normalcy, not pathology. When we are looking for, and can see and know the normal, we diagnose pathology by the process of elimination.

Partial Canal Fillings.—In cases where the canal has a partial filling, and no pathology is shown, the dentist should get as complete a history as possible to avoid the reopening of cases of unavoidable partial pulpectomy. If a vacant pulp canal is shown beyond the canal filling, however, and the tooth gives no response to the vitality tests, a new canal filling should be placed. When there is no indication of an open canal beyond the canal filling, on reopening the case the canal may be found to be completely obliterated as discussed and illustrated in a previous chapter. To find any foramina if they are open, we make a thin paste of iodinized bismuth in camphophenique. Fill the canal full of this paste after previous sterilizing treatments. Then, with a plug of unvulcanized rubber used as a plunger in the cavity, attempt to force this bismuth paste out of the foramina. If any exist, the radiograph immediately following will show their presence.

Multirooted Teeth.—When one or more canals appear as never having been entered, the case should be reopened and the additional pulp canal correctly filled. In case no pathology is indicated at the end of filled roots, they can remain untouched. It is common to see the second canal in the first upper bicuspids entirely neglected. Also the lower cuspids are frequently found with coalesced roots having two distinct canals. This possibility should not be overlooked. With the upper molars their management is so different that we do not advise even a first attempt following pulp putrescence, or a second attempt following pulpectomy or unavoidable partial pulpectomy except by operators who have had much experience and when there is no aparent involvement about the apex of the lingual root. Apicoectomy is not advised for the lingual root.

Instruments in Canal.—In a case where the radiograph shows the portion of a broach extending beyond the canal filling which was broken off during the previous treatment, it had best be retreated, the broach removed, and the canal fully filled, or if the broach cannot be withdrawn, apicoectomy may be necessary. Cases are frequently seen where there is no evidence of periapical pathology from broaches in the apical region. This can be explained by the fact that the broach was sterile, and was smooth so that it completely filled the canal. Barbed broaches, however, never fill the canal. In considering these cases attention must be given the fact that many canals have been filled with silver center gutta-percha canal points used in fine canals with small foramina, a very excellent practice, but sometimes mistaken for broaches. These extend the entire length of the canal and are not tapering as are broaches.

Technic of Removing Previous Canal Fillings.—Remove the filling or crown. Wash cavity with water. Place the rubber dam. Sterilize the field. Make room for direct access to the canal. Apply a stream of hot air from the chip-blower till the exposed gutta-percha is very soft, then remove with excavators and small engine burs. At this point in the operation investigate the possibility of any additional unfilled pulp canals when such are suspected or possible. In case one is found, the treatment and filling of this canal should be followed out and completed before the filling is removed from the partially filled canal. In some cases the pathology seen at the apex of a first upper bicuspid is all from the ignored and unfilled canal and the removal of the previous filling in the other root is not necessary. In renewal cases, however, the two canals should be treated and filled as though they were separate teeth.

Removal of Gutta-Percha Canal Fillings.—Direct a stream of hot air from the hot-air syringe to soften the rubber. Remove as much as is possible with excavators and burs. Again apply the hot air. Flood the chamber and canal with camphophenique, which is a solvent for the gutta-percha point. Penetrate as far through or by the side of the filling as possible with canal reamers of suitable sizes, frequently wiping them clean. In addition to the gutta-percha, the canal may be coated with varnish. Such a combination is now best removed by flooding the canal with chloroform and eucalyptol, followed with instrumentation using reamers. When the previous canal filling has been removed, the usual treatment as outlined in previous chapters is to be followed.

Broken Broaches in Pulp Canals.—If the steel broach is smooth and sterile and has been driven tight and flush with the foramen, or has been entirely surrounded with pulp canal varnish, it makes an excellent and durable canal filling. The above conditions seldom obtain, however. The instrument is generally a reamer or a barbed broach with space all about it. The accident generally occurs before sterilization is complete, and generally much short of the foramen. When such an accident occurs, the broach must be removed, or a passage made around the broach to treat and fill the foramen, or a window may be cut through to the root for the removal, or a subsequent apicoectomy performed. Short of this the tooth should be extracted. The above are the possibilities in dealing with previous pulp canal surgery as related to broken broaches.

Apicoectomy.—Following pathology, on roots the canals of which have long been filled, apicoectomy had best not be done until the operator has assured himself of a tightly fitted canal filling at the point of intended amputation or has made a new one at the time by way of the surgical opening. Some operators advise thus filling the canal at the same sitting, following amputation of the root and before closing the wound, using gutta-percha, or a metal such as lead, gold, or amalgam. Such practice might be tolerated where haste is an essential feature, but a greater percentage of failures to obliterate pathology is prognosed.

CHAPTER XLVI

THE FILLING OF PULP CANALS (MECHANICAL)

It is necessary to fill pulp canals following the removal of the pulp, to prevent the exit of bacteria or other products to the tissues beyond the foramen, and to prevent the dissolution of the encompassing walls of dentine.

A pulp canal is ready for, and should receive, the filling when the canal is void of all but air and when it is not necessary to reach the pericemental tissues again for treatment. To render a canal void of all but air is by no means universally easy, yet it is the object sought, and the conditions are not ideal until this result is obtained. This involves the removal of all pulp tissue, moisture, bacteria and their products, as well as all medicines and chemicals used in the process of treatment.

The perfect pulp canal filling is one which permanently occupies the entire space of the canal and closes the apical foramen to the exit or entrance of all substances, particularly gases and fluids.

The requirements of a material for filling a pulp canal are: that it be insoluble in the fluids of the body, nonirritating to soft tissues, permanent as to bulk and consistency, not subject to putrefaction or chemical changes, and capable of easy introduction. It is an additional virtue if the material used can be removed from the canal after months or even years of occupancy.

The objective point in pulp canal filling is in the region of the foramen. This point must be reached, made surgically and therapeutically clean, completely vacated, and then permanently sealed with a suitable material.

Small canals, particularly if they are tortuous, are a hindrance to attaining ideal results, and even, in rare cases, thwart the effort to save teeth thus afflicted.

The means of cleansing and vacating small and tortuous canals are both mechanical and chemical.

It is best accomplished mechanically by the use of small, flexible, blunt-pointed twisted reamers, which enlarge the canal to the extent of entrance by cutting away sides to increase their caliber until broaches of other forms will be admitted. This process may be assisted chemically by flooding the canal with a 50 per cent solution of sulfuric acid, as this will dissolve and soften the dentine walls, thus facilitating the enlargement of the canals. This method is little used by the author.

In cases where the root is bent on its long axis it is essential that the broach should be rounded and blunt of point that it may follow the canal and not cut its side wall at the bend of the canal, which will produce a shoulder and hinder further progress. This is essential with the finest of broaches and requires preparation on the part of the dentist of every broach used in this class of work, as most broaches that come from the factory have a very sharp point entirely unfitting them for opening bent canals. This blunting process is best

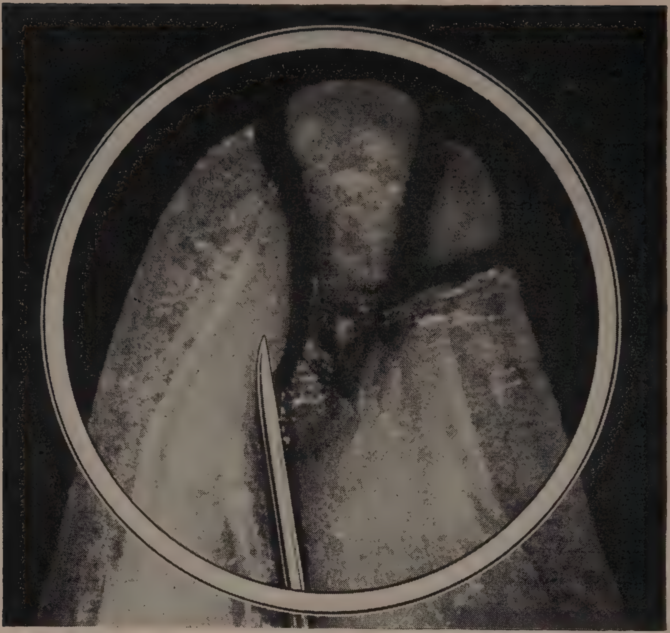


Fig. 376.—Illustrates how a sharp-pointed broach leaves the canal at a bend to make a shoulder to prevent further advance, particularly if the broach is large enough to resist bending.

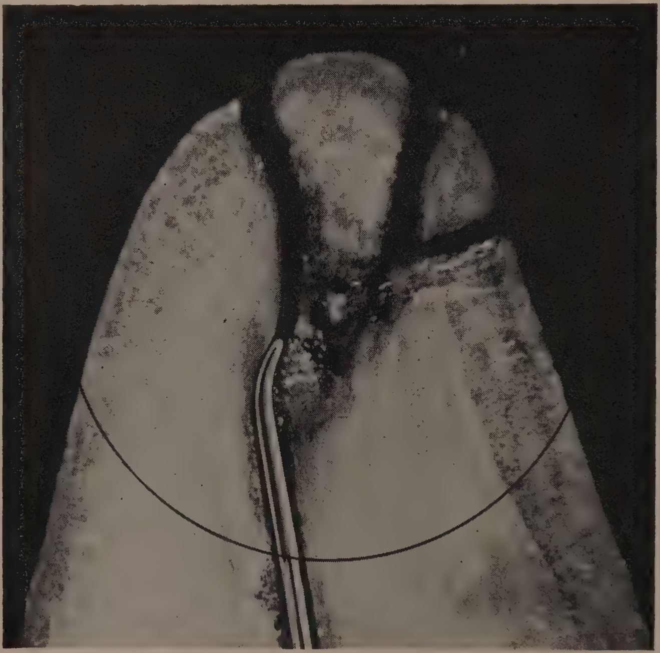


Fig. 377.—Illustrates how the rounded point of a fine broach will follow a curve in a pulp canal. This and the previous figure are photographs, not drawings.

accomplished by holding the end of the broach at an obtuse angle on the face of a fine stone while revolving in a dental engine, at the same time twisting the broach from right to left. (See Figs. 376 and 377.)

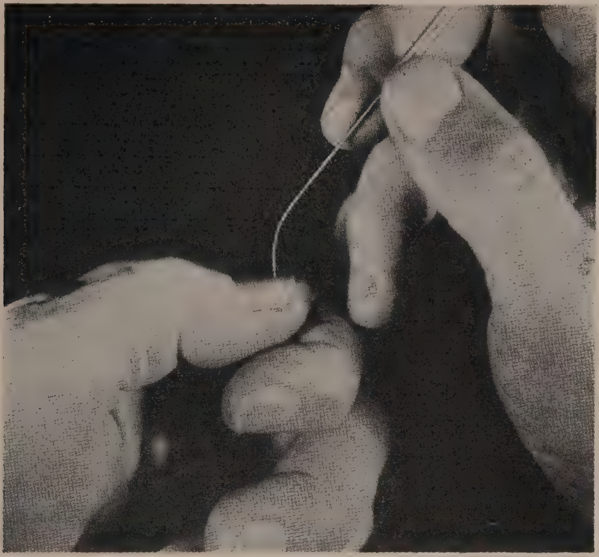


Fig. 378.

Fig. 379.

Pulp canal fillings by classes, as classified for treatment, are given at the close of Chapter XXXVIII. Pulp canal fillings should also be considered, however, under a classification which deals with them from the physical standpoint, that we may take into account the mechanical difficulties encountered due to tooth root anatomy, as to size, length, and form, which must be overcome with each individual canal filled.

The ideal pulp canal is straight and uniformly decreases in size from the floor of the pulp chamber to a single foramen, the smallest lumen of which is close to or at a single foramen.

Fig. 377 shows a round-pointed broach which readily passed out through one of the foramina to the end of the root. Ordinary stock sharp-pointed broaches failed to pass through any one of the foramina. After one of these had been made to progress as far as possible, this tooth was sectioned and a photomicrograph taken which shows very clearly in Fig. 376 how these sharp-pointed broaches become engaged in the side walls of the pulp canal. A round-pointed explorer had previously passed out through the end of the root through the canal (Fig. 377).

Figs. 378 and 379 illustrate a very simple test to determine whether or not that individual instrument is fitted to do pulp canal work. Broaches usually come from the factory with a sharp point. This may be ascertained by placing the broach on the thumbnail as shown in Fig. 378, and pushing the instrument toward the hand. If the point is sharp it will catch on the smooth surface of the nail and bend as shown in Fig. 378. If the point has been rounded, it will readily glide over the fingernail, as shown in Fig. 379, even though quite a little pressure is put upon the point.

Such broaches freely pass around the curves in pulp canals. Such specially prepared broaches may not be had on the market. This is particularly essential with the finest of broaches, and requires preparation on the part of the dentist of every broach used in this class of work which has not been previously prepared in this special manner.

Figs. 380 and 381 are photomicrographs of ordinary stock broaches as they are usually found on the market. Figs. 382 and 383 are photomicrographs, which show these instruments after they had been treated with the blunting process as previously outlined. This change in the end of the broach is much more accurately done by the manufacturer, and the purchase of such broaches is advised when they are available.

Another very serviceable instrument is made by taking a smooth broach and grinding a bibeveled edge on the end of the broach, so as to make it the shape of a cold chisel. This is shown in Fig. 384. This is used with a chopping motion. Because of the flexible shank the instrument will follow the line of least resistance, and may be made to open up very crooked pulp canals.

Care of Instruments.—Rubber dam clamps should be sterilized following each case and placed in a small Petri dish containing equal parts of alcohol and glycerin. Engine burs should be brushed with a metal brush, sterilized, and placed in a Petri dish also containing equal parts of alcohol and glycerin. Absorbent points (J & J) should be wrapped in gauze, sterilized, and kept ready for use in small glass-covered jars.

Blunt-pointed diagnostic wires should be passed through the open flame just before using. All barbed broaches, Kerr files, and twist broaches should be wrapped in gauze, sterilized, and kept in a glass jar ready for use. There should be a separate package of these for each individual case. Gutta-percha points should be wrapped in gauze, sterilized with moist heat, and not unwrapped until just before using. The package should be again put through the sterilizer after each time it has been opened.

Fig. 380.

Fig. 381.

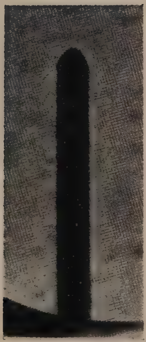


Fig. 382.

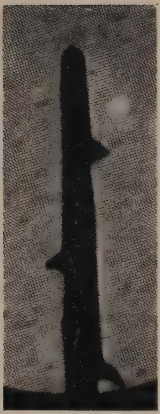


Fig. 383.

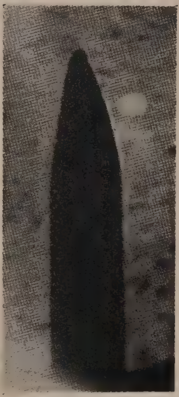


Fig. 384.

Materials for Pulp Canal Fillings.—At this time there are several materials advocated. However, they are all based on the use of the gutta-percha point. These gutta-percha points are used in connection with the varnish, particularly in cases following partial pulpectomy. Gutta-percha points are also used in connection with a sterilizing cement when the pulp canal filling is made following the treatment of putrescent cases.

We will give two formulas for canal varnishes:

Chloroform and Rosin Solution (The Callahan Varnish).

White rosin	4 grains
Aristol	2 grains
Chloroform	1 dram

Rubber Rosin Solution.

The author recommends the following modification of the Callahan varnish as it is possible to make this solution with about twenty times more solid matter than there is in the Callahan varnish, and yet the material will not be stringy. Also the pure gum renders the material very adhesive and is not acted upon so as to loose the fluid portion. A bottle of this varnish may be left unstoppered for weeks and lose no appreciable amount as to bulk.

The author has designated this material as *Pulp Canal Seal,* the formula of which is as follows:

Chloroform	1½ drams
Rubber containing sulfur (tire gum)	4 grains
Eucalyptol	½ dram
White rosin	16 grains
Dithymoldiiodide	4 grains

Proper consistency should be maintained by subsequent additions of chloroform.

Technic of Filling Pulp Canals.—Technic of filling pulp canals following operations on the vital pulp or the more or less complete removal of the vital pulp has already been given in Chapter XL.

Filling Canals With Gutta-Percha.—It should be borne in mind that the completed root filling should contain as much gutta-percha as possible and only a sufficient amount of the fluid portion or varnish to seal the gutta-percha to the walls of the pulp canal. In the best of varnishes the fluid content is not entirely permanent. Canal must be entirely vacant except the air which it contains for its entire length, not forgetting that this includes the removal of all moisture possible.

The first step is to moisten the canal with eucalyptol, taking out excess with absorbent points (J & J). Next replace the air in the canal with a semifluid solvent of the gutta-percha point. This may be either one of the two varnishes, the formulas of which have been previously given. The introduction of the fluid part is accomplished by dipping a small broach into the container and carrying the broach thus loaded to each canal, carrying the same to the accessible foramen by a pumping motion.

The varnish is made to replace all air and moisture so that these may not be imprisoned within the canal. The introduction of the gutta-percha canal point is here accomplished by grasping the large end which may have been previously flattened with the cotton pliers or by attaching it to the warm end of a canal plugger. Withdraw the smooth broach which has been allowed to remain partly within the canal, and immediately enter the small end of the gutta-percha point shoving it entirely to place by a steady gentle pressure.

The canal point should then be moved back and forth several times with a slight pumping motion for a distance of only one or two millimeters. This will assist in closing the mouth of the accessible foramen, and will cause the solution to travel laterally into the lateral canals in so far as they have been vacated. This method has been designated by Dr. Rhein as "mortarization."

The student is advised before using this root filling to familiarize himself with Dr. Rhein's technic, as well as a modification of this technic given by Dr. Johnston of Atlanta, Georgia.

The canal point should be large enough to entirely fill the canal. It should be about one millimeter longer than the canal to permit of slight tamping at the mouth in the floor of the pulp chamber. The size must have been previously ascertained by measurements with a root canal gauge.

The first mechanical procedures, looking to the filling of pulp canals, are those made in an effort to change the canal to that of the ideal shape, that is, to make crooked canals more nearly straight, and those having rough sides less rough. Ream out all canals with reamers and screw threaded files so graduated that the smallest caliber of the canal is farthest from the pulp chamber. It is physically impossible to pass a solid gutta-percha canal point through a small opening to fill a canal of larger caliber beyond, to say nothing of filling two or more foramina upon approaching near the canal ends.

Fluidity as a Part of the Canal Filling.—To overcome these difficulties so frequently met with, the solid part of the canal filling is set in a fluid previously placed in the canal. In ideal or nearly ideal conditions as previously described, a varnish made of rosin dissolved in chloroform, clear or modified, is at this time the most popular to use in connection with gutta-percha points.

Silver-Center Canal Points.—When the canal is extremely small, and the graduation in caliber slight, the silver-center canal point set in varnish is of service.

The presence of the silver wire as a core in the center of the gutta-percha makes it possible to push the point to the farthest end of the canal opening. (See Figs. 385 and 386.)

The use of these points is not indicated if the canal filling is to be followed by the mounting of a pin crown or by apicoectomy, as the canal filling is liable to be pulled from the canal.

The Filling of Canals Beyond the Point of Instrumentation.—Filling pulp canals following partial pulpectomy, unavoidable and intentional, has been covered at the close of Chapters XXXIX and XL, respectively.

When there has been pulp death and more or less evidence of inflammatory processes in the pericemental tissues, however, and the pulp canal is impossible of instrumentation to its natural foramen or foramina, apicoectomy (Chapter XLVII) is many times the only safe procedure following thorough medication and the placing of the most complete canal filling possible. This will necessitate the removal at times of as much as the apical third of the root, as illustrated in Figs. 387 and 388.

Use of a Paste in the Inaccessible Part of a Canal.—There are several recommended compounds on the market. The author prefers an iodinized bismuth paste in a solution of camphorated phenol, mixed in the pulp chamber with the previously mentioned varnish, and pushed to all exits with pressure by the use of a ball of unvulcanized rubber, to be followed by the gutta-percha point pushed to the farthest point of previous instrumentation.

We have been pleased to see the previous pathology disappear while waiting for the possible apicoectomy.

The Overfilled Canal.—After checking over 550 x-ray series for a period of years, it would seem that overfilling is a lesser evil than failing to reach the foramen in canal filling following complicated putrescence. With the overfilled canal there is a greater probability of a tightly filled foramen. A slightly protruding gutta-percha point with or without the silver center becomes surrounded by a connective scar tissue as does a lead bullet.

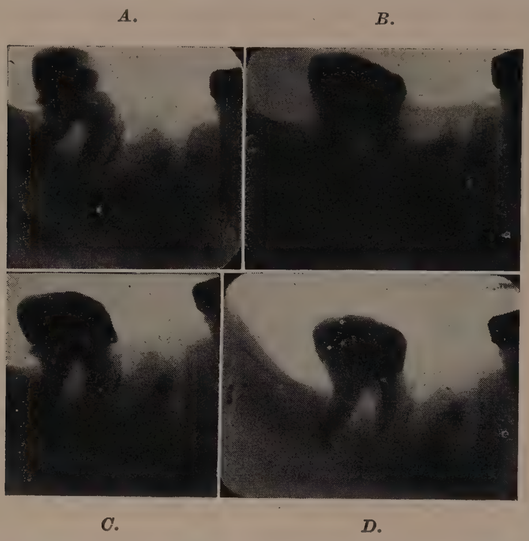


Fig. 385.—Clinical Case 434. Complicated acute putrescence without fistula. *A.* X-ray before treatment. *B.* X-ray, first treatment. *C.* X-ray of filled distal canal with gutta-percha point and varnish mixed with bismuth. *D.* X-ray of dressing in mesial canals, as far as broaches would go.

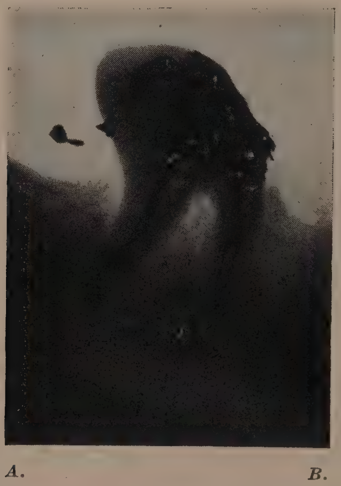


Fig. 386.—Clinical Case 434. X-ray shows mesial canals filled by force with varnish impregnated with bismuth paste, followed with Miller's silver-center canal points as far as they would go.

In canal fillings coming short of the foramen but reaching beyond the dentine in the canal, the majority, if all in cementum, are later obliterated by the deposit of new cementum. The process is accomplished by some of the primary cementum being carried away before Nature places the new cemental coating.

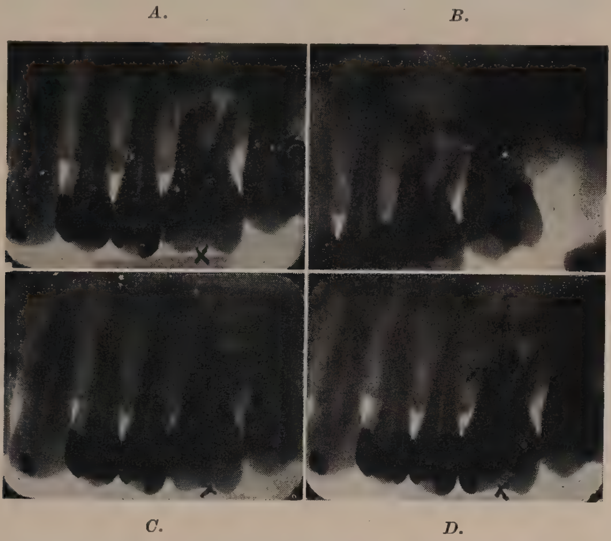


Fig. 387.—Clinical Case 435. Complicated acute putrescence without fistula. *A.* X-ray, first treatment to pulp chamber only, as soreness of the tooth prohibited the placing of the rubber dam the first sitting. *B.* X-ray, second treatment. *C.* X-ray, third treatment and filled lingual canal with gutta-percha point set in varnish. This canal was covered with amalgam. *D.* X-ray, filled buccal canals. Distobuccal with Miller's silver-center canal point set in varnish. The mesiobuccal was forced full of varnish and iodinized paste beyond point of instrumentation.

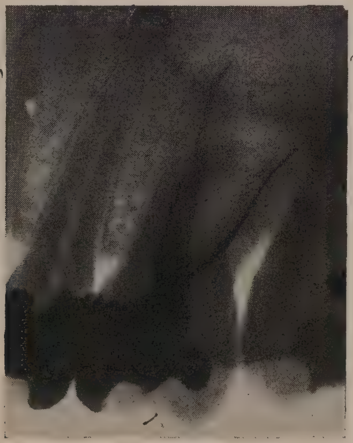
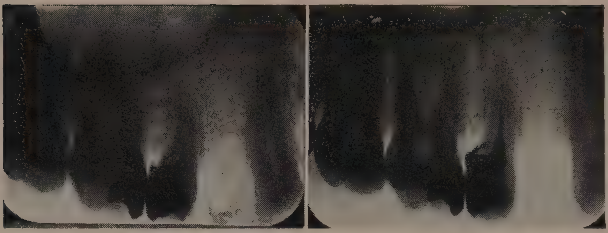


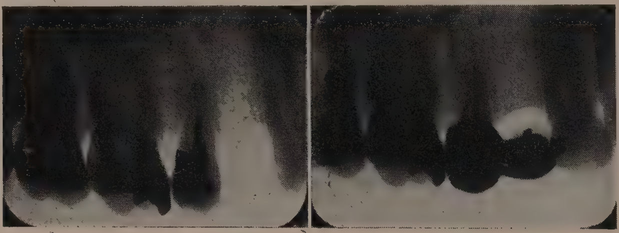
Fig. 388.—Clinical Case 435. X-ray shows this complicated case three months after canal filling.

This complete closure is proved by opening cases after some years of short primary filling, and testing by attempting to force a radiopaque semifluid beyond the tooth apex.



A. *B.*

Fig. 389.—Clinical Case 331. An eight-year-old partial pulpectomy by a Lincoln, Nebraska, dentist. *A.* X-ray, before removing old canal filling. *B.* X-ray after iodinized bismuth paste was placed in canal and high pressure used with unvulcanized rubber. No opening was shown.



A. *B.*

Fig. 390.—Clinical Case 331. *A,* X-ray of filled canal a little farther than the original which seems to be a lateral canal in a slightly bifurcated apex. *B.* X-ray shows checkup three years after canal filling.

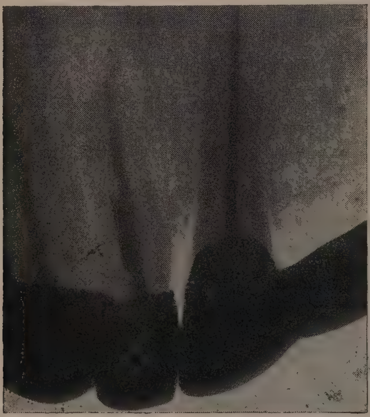


Fig. 391.

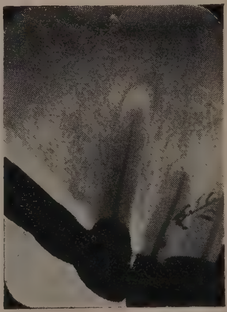


Fig. 392.

Fig. 391.—Clinical Case 410. Complicated putrescence, punctured root. Fistula from puncture on labial. Used bone wax to fill puncture before placing canal filling of gutta-percha set in varnish. X-ray taken (day operation was completed.)

Fig. 392.—Clinical Case 410. Lateral incisor five years after the use of bone wax in a punctured pulp canal. Cuspid was to have apicoectomy but patient objected.

Such a testing mixture is made by making an iodinized bismuth paste quite thin with camphophenique. This is pumped as far as possible with a smooth broach and then force is applied with a ball of unvulcanized rubber. (See Figs. 389 and 390.) The x-ray will detect any open canals.

Perforated Roots.—We occasionally are called on to treat and fill pulp canals of a tooth the root of which has been punctured by the dentist in an effort to locate one of the canals, or there may be a hole in the floor of the pulp chamber of a molar between the roots. After one or two treatments for disinfection the opening may be closed prior to the canal filling with a bone-stimulating wax, the formula for which is 1 part bismuth subnitrate in 2 parts by weight of a high-fusing paraffin at about 120° F.

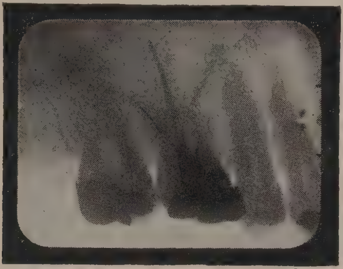


Fig. 393.—Clinical Case 299. Complicated putrescence in all three canals. X-ray shows lingual and distobuccal canals filled. Mesiobuccal impossible to fill.

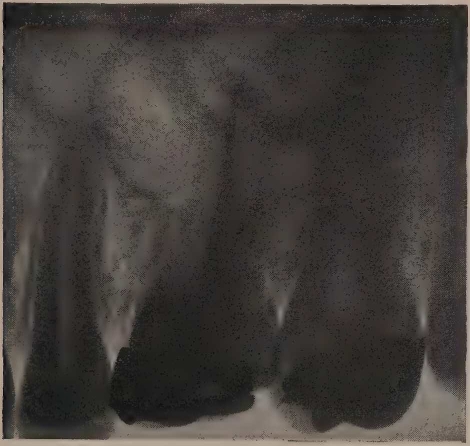


Fig. 394.

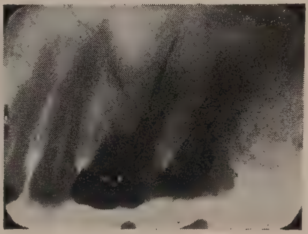


Fig. 395.

Fig. 394.—Clinical Case 299. X-ray following complete root resection of mesiobuccal root.
Fig. 395.—Clinical Case 299. X-ray shows case five years after treatment and surgery.

The opening is made vacant and a piece of this wax compound is placed over it and melted to place with a suitable warm instrument. The canal filling is then proceeded with in the usual manner.

The major portion of the wax is later replaced with bone or cementum or both, owing to the location of the puncture. (See Fig. 391 which is a case so filled, x-ray being taken day of filling.)

Root Amputation.—With upper first and second molars in putrescent cases having exceedingly crooked mesiobuccal roots, it is sometimes safer and quicker to remove the entire root after filling to the limit of instrumentation. (See Figs. 393, 394, and 395.)

Management of Complicated Cases of Multirooted Teeth.—We frequently have cases presented in the molars with each one of the three pulp canals in

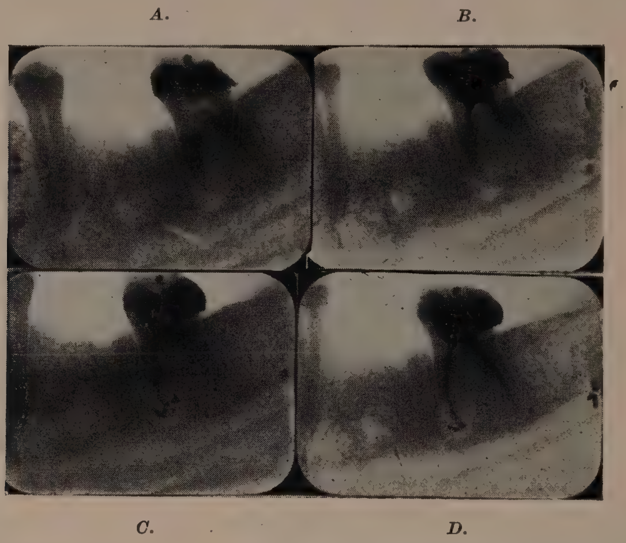


Fig. 396.—Clinical Case 319. A complicated case of putrescence in the mesial canal and vital pulp in the distal canal. *A.* X-ray before treatment. Note granuloma at apex of mesial root; also two granulomas mesial of the tooth, where a dentist had extracted a pulpless tooth and failed to curette the sockets, patient reported. *B.* X-ray, first treatment. A silver filling was placed temporarily over the vital distal pulp. Iodinized bismuth paste was placed in the pulp chamber. *C.* X-ray, second treatment of mesial canals. *D.* X-ray of dressing in distal canal following pulpectomy in distal root.

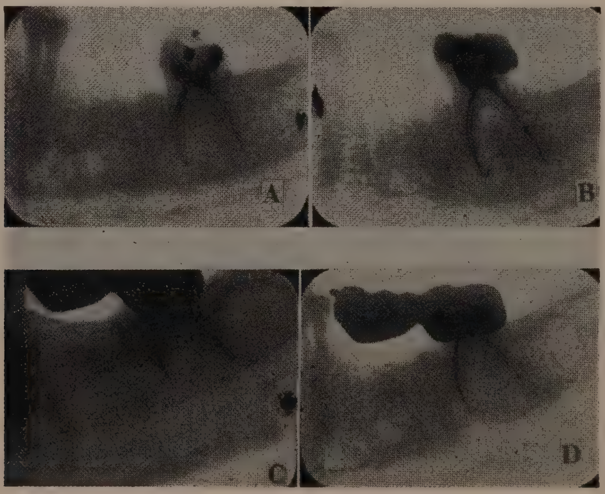


Fig. 397.—Clinical Case 319. *A.* X-ray of filling in distal canal. *B.* X-ray shows all canals filled. *C.* X-ray one year later. *D.* X-ray five years later. Note the repair about the treated root and the persistent areas at place of extracted tooth just anterior.

a different stage of disease and require handling as distinctly as though the canals were each in a different tooth. Figs. 396 and 397 show such a case. The distal root was vital and required pulpectomy. The mesiobuccal canal was entirely putrescent, complicated with a well-defined granuloma. The mesiolingual canal was semiputrescent with vitality within the canal close to the foramen. The last checkup shows the condition five years after canal fillings were placed. Note the two areas anterior to the case which were latent following the extraction of the first molar some time before, wherein the dentist failed to curette the sockets. These have remained, yet the area at the apex of the putrescent root has entirely disappeared.

CHAPTER XLVII

APICOECTOMY AND CURETTEMENT

Definition.—Apicoectomy is the term applied to the operation of excising and removing the apex of the root of a tooth. The word is a combined word, Latin *apex,* the end, *apico,* the combining form meaning related to an apex, and the Greek *ektome,* excision. The word ''apicoectomy'' is preferable to the term ''amputation of the end of the root.''

Dentistry has been replete with many long phrases, descriptive of certain conditions and operations, which should be in the discard, and in their places words should be used which find their inception in the general practice of medicine.

When Indicated.—First, when pathology is shown about the apex of a tooth which seems to have a satisfactory appearing canal filling to the root end.

Second, when indications of pathology persist about the root end of a tooth which has recently had a canal filling and has been known to house putrescence, a reasonable time for recovery having been allowed.

Third, when the bismuth paste injections have shown a denuded root end.

Fourth, when the accessible foramen is much larger than the lumen of the canal just crownwise, as a tightly filled foramen in such cases is not common.

When Contraindicated.—First, when the roots are so situated that the operation is liable to result in an unwarranted injury. This objection eliminates all molar teeth, particularly the lower molars, also the lower bicuspids on account of their apices being so close to the mental foramen. Operations close to the exit of the labial branch of the mandibular nerve frequently result in a paralyzed lower lip. The location of the foramen as related to the individual teeth in question should always be given consideration before deciding on apicoectomy.

Second, when the supporting structures have been so far removed through gingival disease that the tooth has much preternatural mobility.

Cause.—The causes leading to a demand for this operation to avoid extraction are: First, the presence of many inaccessible foramina opening to the pericemental tissues from infected canal branches.

Second, failure of the canal filling to seal hermetically the foramen where but one exists.

Third, where there is nonvital cementum, that is, cementum which is not attached to a vital pericementum and is therefore sequestral, and Nature seems to refuse to remove this for the building on of new cementum.

The Anesthetic.—The operation is limited in area and so accessible that a general anesthetic is not indicated. The author generally uses infiltration, with block anesthesia in extremely nervous or sensitive patients.

Technic of Apicoectomy.—The field is sprayed with an antiseptic solution of which Sodiphene is an example. The lips are packed away from the field with cotton rolls. A semilunar flap is made through the mucoperiosteum on the external side of the root with hinging side of the flap toward the lip and about level with the apex of the tooth. The flap should not approach nearer than ¼ inch to the gingival border (Fig. 398). This flap is retracted (Fig. 399) and the bone removed with an engine bur to expose fully the portion of the root to be excised (Fig. 400).

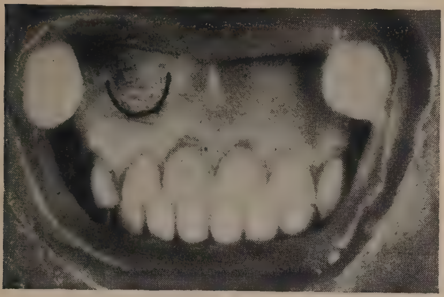


Fig. 398.

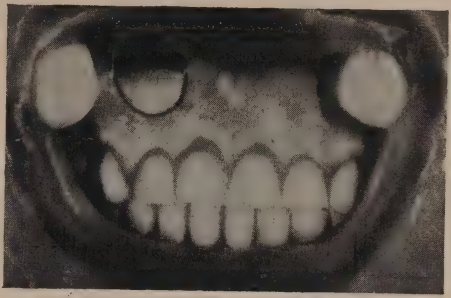


Fig. 399.

Fig. 398.—Apicoectomy. Outline of flap. (Wax models by Dr. C. F. McAdams of Lincoln, Nebraska. Etchings of the surgery by the author.

Fig. 399.—Apicoectomy. Mucoperiosteal flap lifted.

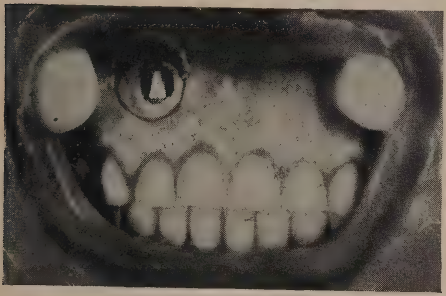


Fig. 400.

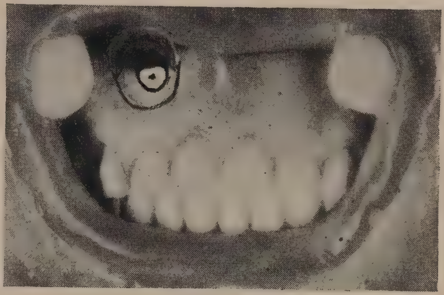


Fig. 401.

Fig. 400.—Bone removed, exposing portion of root to be excised.

Fig. 401.—Apex of root amputated and made cup-shaped.

The granulation tissue is then curetted entirely from about the root end. This curettement is advised at this time as it will determine the outline of the denuded, hence dead, cementum. The root end is then excised straight through at a right angle to the long axis of the tooth and on a level with a gingival point of the denuded cementum. A new crosscut fissure bur of medium size is best adapted for this purpose. A chisel has no place in this operation. Slivers of bone may result in sequestra, and slivering of the tooth's root may result in delayed repair or even failure of the operation. Next, with a large round No. 6 bur proceed to make the end of the root shaped like the inside of a cup, concave, with the canal filling in the center and lowest part (Fig. 401). It is taken for granted that the root canal has been recently rendered sterile as well as the dentine, and the canal solidly filled by a method and with a material which renders it permanent in character, nonsoluble in the fluids of the body, given to the minimum of dimensional change, and adhesive to the walls of the canal. Such a filling may be of either gutta-percha or lead, set in varnish. When the root has been made cup-shaped as described, the end of the cut-off canal filling should be burnished and pressed to a close fit, be it either lead or gutta-percha. In the latter case the burnishing instrument should be slightly heated. The shape of the remaining root end is very important from a biologic and histological standpoint. Most of the failures resulting from apicoectomy are due to leaving a rounded root end, or one shaped like the end of the finger sticking up into the cavity. We are operating to get rid of dead cementum in contact with vital tissue to which the vital tissue refuses to become attached. A rounded root end has the maximum of dead cementum and dentine and the case is little better than it was before the operation. With a cup-shaped root end wherein the entire periphery is attached to vital cementum, there is no dead cementum left in the wound. This has a marked effect upon the process of repair. Cementoclasts develop at the border of this thin edge of vital cementum and begin the tearing down of the cementum at once, as all cemental cells are vital cells and have a direct connection with the pericementum.

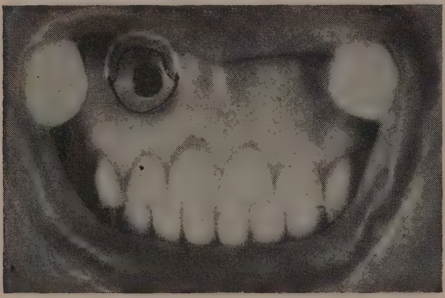


Fig. 402.

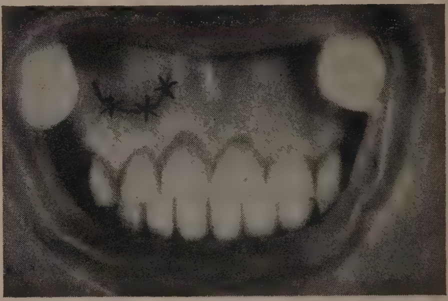


Fig. 403.

Fig. 402.—Bone wound filled with blood.

Fig. 403.—Flap replaced and stitched to place with Luken's Exodontia Catgut, 4-day sutures. See that the wound is filled with blood after stitching.

Following the cupping out of the root end, the entire wall of the bony pocket should be freshly curetted to open into the medullary spaces.

The wound is then given a generous bath of recently boiled water containing a little less than 0.9 per cent of salt. This bath should remove all debris of bone and tooth particles. The pocket then is filled with blood (See Fig. 402). The mucoperiosteal flap should be closed with three stitches (Fig. 403).

A pointed sterile instrument should be passed between the stitches to tissue above the wound and a hemorrhage induced to fill the wound cavity with a fresh supply of blood. The resulting blood clot will assist the osteoblasts in the bone repair, and in replacing the cementum as rapidly as the cementoclasts level the end of the root. Nature may restore the apical end removed by surgery. (See Figs. 404 to 407 inclusive.)

The root will eventually be made round, entirely covered with a thin layer of new cementum, and topped with a new pericementum, except the point of contact with the canal filling where there will be a thin layer of connective cicatricial tissue. Outside of the pericementum the normal lamina of condensed bone should appear, as shown by the x-ray. Failure to make such repair in the usual time of general bone repair would indicate the continuation of infection,

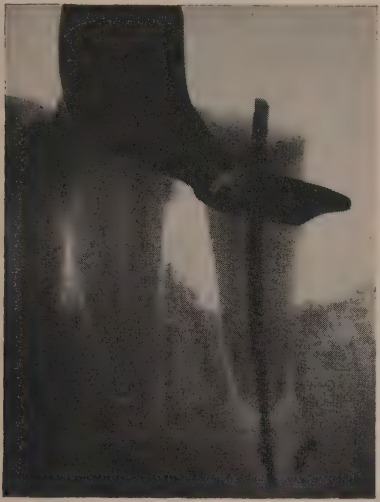


Fig. 404.

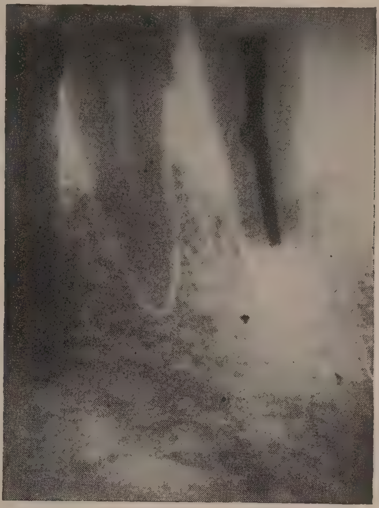


Fig. 405.

Fig. 404.—Clinical Case 280. X-ray on day of canal filling following treatment for chronic complicated putrescence without fistula. Purposely overfilled and allowed to stand three months before operating.

Fig. 405.—Clinical Case 280. X-ray taken day of apicoectomy.

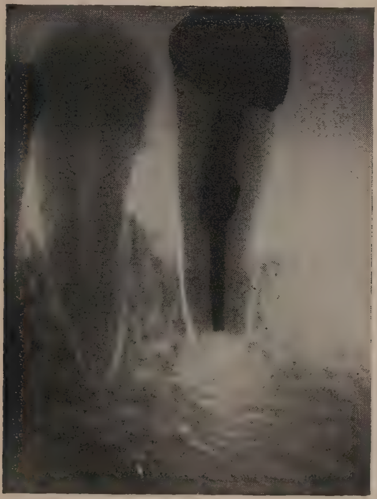


Fig. 406.

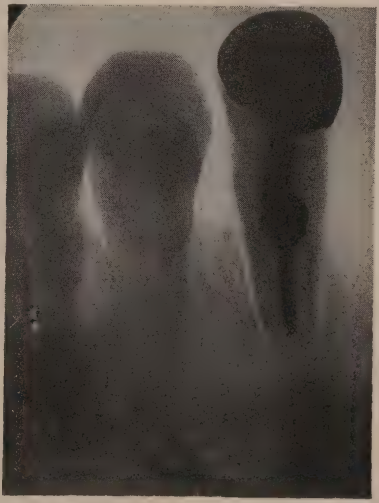


Fig. 407.

Fig. 406.—Clinical Case 280. Six months after operation of apicoectomy.

Fig. 407.—Clinical Case 280. Five years after the operation of apicoectomy. A new root end has been builded on the tooth.

and the removal of the entire root is advised. Operators who are practicing apicoectomy, however, report all indications pointing to as frequent and complete success as with other bone operations made necessary on account of infection.

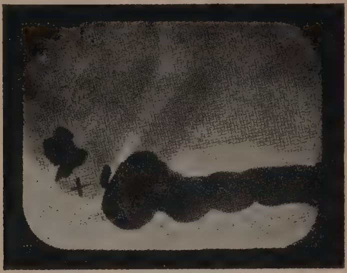


Fig. 408.

Fig. 409.

Fig. 408.—Case of Mr. H. before treatment.

Fig. 409.—Case of Mr. H. after treating and filling pulp canal to excess, as advocated by some but not generally practiced by the the author.

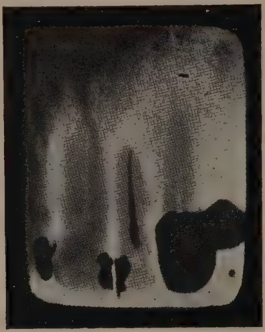


Fig. 410.—Case of Mr. H., two years after filling the root canals and one year after the operation of apicoectomy.

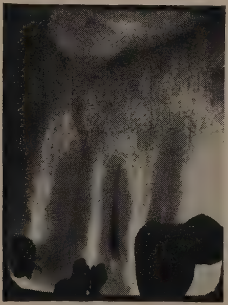


Fig. 411.

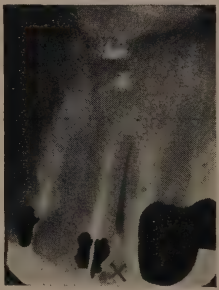


Fig. 412.

Fig. 411.—Case of Mr. H., one year and eleven months after the operation of apicoectomy.

Fig. 412.—Case of Mr. H., seven years after the operation of apicoectomy.

Case Report.—(Mr. H.) We regard this case after this length of time and with the conditions as shown, as a completed case. The history is given in detail from the first visit to the last, which is a period of over seven years.

The author would regard it as ideal if each case could be carried through on as complete an investigation as was this one. This case has been selected on account of the severity of the general systemic manifestations of the absorption of infection before treatment, and also because of the fact that surgery played a part in this case.

Mr. H. came to the infirmary assisted by two trained nurses. He was suffering from acute myositis particularly manifested in the muscles of the arms, shoulders, and back.

A full mouth radiographic series was taken. The condition about the root of the right superior lateral incisor was noted (Fig. 408). Tests proved the pulp in this tooth to be dead. It was determined to treat and fill the pulp canal.

A blood examination was made at this time, the result of which was as follows:

Erythrocytes, about	4,500,000
Leucocytes	15,000
Polymorphonuclear neutrophile percentage:	82

The tooth was opened and treated as previously outlined in this chapter, except that the root filling, as advocated by some, was made to protrude beyond the accessible foramen. The operation was completed six days later.

Fig. 409 is from a radiograph taken the day the root filling was completed. All symptoms of myositis left the patient within a few days. One month after the filling of the pulp canal, a second blood examination was made with the following result:

Erythrocytes, about	4,500,000
Leucocytes	8,000
Polymorphonuclear percentage:	64

There were no outward manifestations of trouble till ten months later when patient returned complaining of pains in the arms and shoulders. Radiographs of the case during these ten months showed only partial recovery.

On the same day, a third blood examination was made with the following result:

Erythrocytes, about	4,500,000
Leucocytes	12,000
Polymorphonuclear percentage:	76

The operation of apicoectomy was performed two weeks later. The end of the root amputated was found to be denuded and coated with a thin scale of salivary calculus. Within two or three days the returning myositis had disappeared.

A few weeks later a fourth blood examination was made, which gave the following result:

Erythrocytes, about	4,500,000
Leucocytes	8,000
Polymorphonuclear percentage:	64

CHAPTER XLVIII

ENDODONTIA FOR CHILDREN'S DECIDUOUS AND PERMANENT TEETH

The pulps in deciduous teeth are exposed to the destructive processes and complications found in the permanent teeth. After pulp infection is once established, it remains active unless the tooth receives treatment or is extracted. The too early extraction causes irregularities in the permanent teeth.

Much more attention should be paid to the prevention of decay in the deciduous teeth. It is best practice to enlarge the fissures and pits of the molars and fill them with silicate. The four intermolar approximating surfaces should be cut with a disk to a separation of about one-half millimeter and the ground surface treated with the Howe's solution of silver nitrate. This should be done in all cases before decay is even apparent in the molar proximal surface as temporary molars seldom go to exfoliation without decay and are responsible for nearly all of the toothaches and alveolar abscesses associated with deciduous teeth.

Teeth so treated will not decay. The contacts of deciduous molars are so bad that decay is inevitable and the opening up of the spaces renders them less retentive of food and possible of taking on the silver deposit. The spaces anterior to these may be left till there is evidence of decay in the proximal surface when they may be filled with silicate.

Vital pulps are not infrequently exposed in deciduous teeth through decay and in the process of cavity preparation. Because of the large foramina (there are four in each temporary molar) the circulation is abundant.

Following partial pulpectomy, such as the removal of a horn of the pulp, a part of a horn, or the entire contents of the pulp chamber, and a sterilizing treatment, there is practically universal success. We have made a practice of this since 1891 and few cases have required reopening for treatment. The pulps have remained vital, and the process of resorption of the roots has progressed in a manner and to a degree comparable with the other teeth in the same mouth not so treated.

Technic.—When the horn of the pulp is exposed through decay or cavity preparation, the pulp should be anesthetized and a sufficient amount of the horn of the pulp cut off to induce a free hemorrhage. The saliva is excluded. The wound is bathed with hot water. Eugenol is then applied to check the hemorrhage. The wound is then dried with sterilized cotton. The wound is touched up with pure phenol, a practice not permissible in permanent teeth. Over this cauterized wound is placed a small quantity of zinc oxide bismuth, oil of cloves paste, as heavy as may be placed without pressure on the pulp. On this is made a soft amalgam filling, with the amalgam in direct contact with the dressing.

When the coronal portion has been involved, it is best to remove the entire coronal portion of the pulp and treat each of the pulp stumps as previously outlined with hot water tampons and eugenol, and place the paste or dressing over the entire floor of the pulp chamber, covering with an amalgam filling in contact with the dressing. Such teeth go on to normal root resorption without pulp death, all of which is a very simple and short operation.

Putrescent deciduous canals are handled in a similar way. However, there is no need for the use of an anesthetic.

Teeth where the decay has penetrated through the floor of the pulp chamber are past retention and should be extracted. Many cases will appear with one or more fistulas on the buccal surface, others when they are about to point. These should be drained at once through small punctures but without curettement. With the rubber dam off, the cavity and pulp chamber are thoroughly excavated and freely washed with water. The cavity is then given retentive form high up in the chamber.

The canals are each broached with barbed broaches to the point of sensation only and freely bathed with water. The saliva is then excluded with packings (or rubber dam), and the area dried and eugenol applied. The excess is wiped away and the canals are each pumped full of iodinized bismuth paste and spread over the floor of the pulp chamber, and the treatment completed with a contacting amalgam filling. The case will heal immediately without pain, the fistula or fistulas will disappear, there will be no further evidence of an infectious process, and the roots will continue to resorb in a manner and amount comparable to other teeth in the same mouth without involved pulp or pulp canals.

The author (with others) has practiced these methods since the time of his graduation (1891). They may not be new to some of the readers but it does no harm to reconsider them as some may have been lax in the way and slipped toward the ''100 per cent'' precipice, and assisted in the education of their patients to believe that ''the removal of infectious processes from living tissue without tissue removal'' is not possible for the dentist.

In closing, let us advise that the filling of pulp canals in deciduous teeth should not be practiced except with materials which will be slowly dissipated at a rate comparable with the rate of root resorption.

CHAPTER XLIX

PROGNOSIS IN ENDODONTIA

Vital Pulp.—Any one of the teeth in the mouth having a vital pulp not grossly infected may have part or all of its pulp removed under aseptic conditions and the tooth remain vital and not develop sepsis or show apical pathology.

Young teeth with large foramina and yet undeveloped roots had best have their pulps amputated at the floor of the pulp chamber. Root development will proceed to completion uninterruptedly. Large undeveloped foramina are rarely satisfactorily filled, except from the apical end.

With adult teeth having fully formed roots, pulpectomy to the accessible foramen should be attempted in all involved pulp cases. If unavoidable, this results in partial pulpectomy with the unobtainable portions of the pulp not traumatized, not destroyed with caustics, and not grossly infected. Then begins a repair process which is a repair of vital tissue and through a tissue metaplasia an osteoid tissue is laid down to a partial and sometimes complete obliteration of the remaining pulp ends. It must be borne in mind, however, that the danger of failure increases in direct proportion to the amount of pulp tissue left in situ in adult teeth where small foramina and restricted circulation exist. This is not the case with large undeveloped foramina.

Use of Arsenic.—We fail to harmonize this vital process of pulp obliteration following surgical treatment with that of our European contemporaries who advocate the practice of leaving in the teeth pulps which are highly inflamed due to infection and possible of removal, the vitality of which they destroy with arsenic. They attempt to preserve the remains with chemicals in the canals the pulps have builded. The one depends on the preservation of devitalized flesh, the pulp canal becoming a grave. The other is a process of repair by virtue of the exercise of a vital function. In case the pulp is not fully devitalized with arsenic when attempted, the osteoid tissue may or may not fill the canal.

Vital Foramina.—In the management of all vital pulp operations it is essential that the foramina be left with vital functioning tissue.

Putrescent Cases.—When the pulps have become putrescent through the action of bacteria, the salvage of such cases involves the removal of all end products and bacteria from the pulp canal and the permanent sealing of the foramina and dentinal tubules which are the only routes by which the contents of the canal may reach the surrounding tissue.

Dentocemental Junction.—Contrary to the views and writings of some, the dentocemental junction is impervious to bacteria.

If this were not true, the pericementum opposite positions nearer the gingivae would first began the development of the granuloma, and the apical region would be the last to display evidence of an active resistance.

Toxic Substances.—According to the findings of Dr. Price, the "toxic substances produced by the bacteria can pass the dentocemental boundary, the extent of which is not yet completely determined."

For this passage we must figure on an osmotic current. As is well known, osmosis takes place only between separated fluids of different density. Suitable conditions might obtain while the canal was bathed with end products of a decomposing pulp. However, after the canal has been soaked for weeks in strong antiseptics as previously outlined, rendered dry, and the canal filling sealed to the walls by a varnish that permanently seals all tubules, any osmosis between the protoplasm within the dental tubules, through the dentocemental junction and the body of vital cementum to the periosteum, would be extremely limited, and if it did take place it would be in one direction only, i.e., toward the fluid of the greater density, hence toward the protoplasm in the dental tubules. Again, if such an inconceivable osmosis occurred it would be very minute, or as short-lived as the specific gravity, or the density of the dental protoplasm would soon be the same as that by which it was being diluted.

Osmosis plays a valuable part in treating cases of complicated putrescence and it augurs for the use of a paste for injecting canals, so that the osmotic current may not flow from the apical region to the surrounding tissues, carrying fluid medicaments of a strong irritating nature to a place where they cause pain.

We do not use pulp canal treatments with a specific gravity below or equal to the flowing blood.

Vital Tooth.—So long as the cementum on a tooth, pulpless or otherwise, is attached to a living functioning pericementum, that cementum displays all the activities of vitality found in any tooth, such as dimensional change (growth and resorption), and change in weight, color, density, and qualitative analysis; yet it may be subject to no change which is capable of demonstration. Such a pulpless tooth, the canals of which have been obliterated by an osteoid formation or a sealed-in canal filling, can by no stretch of the imagination be classified as a sequestrum, as there is nothing sequestral about it till the pericementum is detached and vital phenomona have ceased. When such detachment takes place surrounded by vital tissue, there exists an attached sequestrum, and apicoectomy may eliminate all that is sequestral, or extraction may be indicated.

Finally, prognosis is as favorable following pulp canal surgery and therapy as it is following similar procedures in cases of bone infection in other parts of the body, the practice of which is not even questioned in the general practice of medicine. If curettement and medication are good practice on one side of the floor of the maxillary sinus, it certainly may be practiced on the other side of the floor without extraction.

In systemic disorders known to result from streptococcic infection, as large a percentage shows improvement or relief following the therapy and surgery herein outlined as follows tooth extraction.

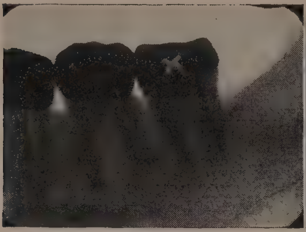


Fig. 413.

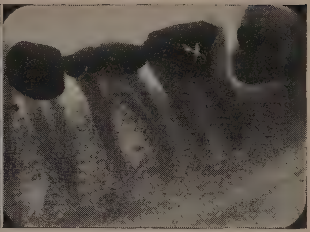


Fig. 414.

Fig. 413.—Clinical Case 342. Complicated chronic putrescence without fistula. Dentist had attempted pulp mummification. X-ray before treatment.

Fig. 414.—Clinical Case 342. X-ray two years after canal filling.

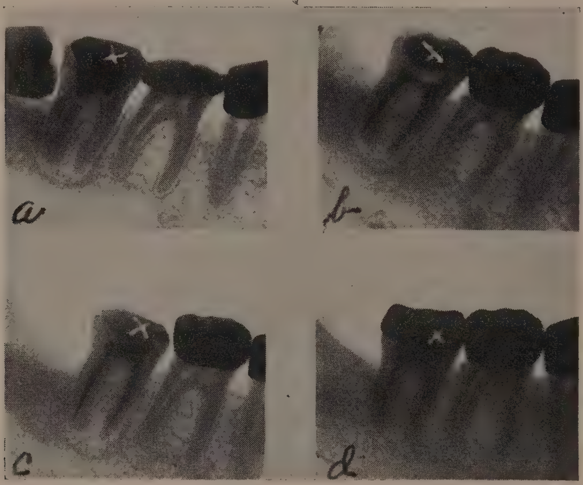


Fig. 415.—Complicated putrescence. *A.* Before treatment. *B.* First treatment. *C.* Pulp canals filled. *D.* Ten years after filling.

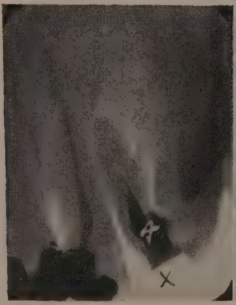


Fig. 416.

Fig. 417.

Fig. 416.—Clinical Case 174. Simple putrescence. Vital at the foramen. X-ray before treatment.

Fig. 417.—Clinical Case 174. X-ray twelve years after treatment and canal filling.

Many times, the indications of bone repair and the obliteration of granular areas about the apices of infected teeth will be manifest sooner and more completely regenerated following correct canal filling than following extraction. (Refer to Fig. 397, Chapter XLVI as a case in point.)

The replacement of granulation areas with bone is a very sure and easy matter when the putrescent pulp canal walls have been saturated with iodine and the canal space has been filled permanently with an inert and neutral substance, such as a gutta-percha point set in varnish.

Much dentistry that is now daily taught by nearly all of our dental colleges, which include the greatest pathological laboratories in America, is condemned because the above statement is not known or believed. Verify the above statement by a little correspondence.

The fees must be commensurable with the time such operations take and the services rendered.

Making Anatomic Mounts

Laboratory technic used in the study of the anatomy of the apical third of tooth roots is as follows:

1. Place the tooth as soon as possible in a 1 per cent aqueous solution of Lysol till needed. Use teeth without decays.
2. Wash one hour in running water.
3. Thoroughly expose each pulp at the cervix.
4. Alcohol 50 per cent, six to 12 hours.
5. In carbolfuchsin stain, twelve hours.
6. Wash several minutes in tap water.
7. Grind to a thin section through any desired plane, grinding from both sides and keeping moist all the time.
8. Photograph with strong transmitted light.
9. Preserve for future use in Carbo-Zylol.

The glycerin mounts are prepared by the following technic:

1. Extract teeth and place in a 1 per cent aqueous solution of Lysol.
2. Saw off the crowns at the cervix.
3. Boil five minutes in a 2 per cent aqueous solution of sodium hydroxide.
4. Wash five minutes in hot water (not boiling).
5. Wash one hour in cold running tap water.
6. Soak in gasoline twelve hours.
7. Fill canals with a wax paste:
    Dissolve yellow wax in gasoline to the consistency of cream.
    Stain bright red with mercuric sulfide.
    Pump canal entirely full and, if possible, force past the foramina with pressure.
8. Allow to stand for twelve hours in the open air.
9. Decalcify in a 5 per cent solution of nitric acid, using a dram of the solution for each root. This decalcifying process takes six or seven days.
10. Wash one hour in tap water.
11. Mount on cork with phonograph needle and suspend in glycerin.

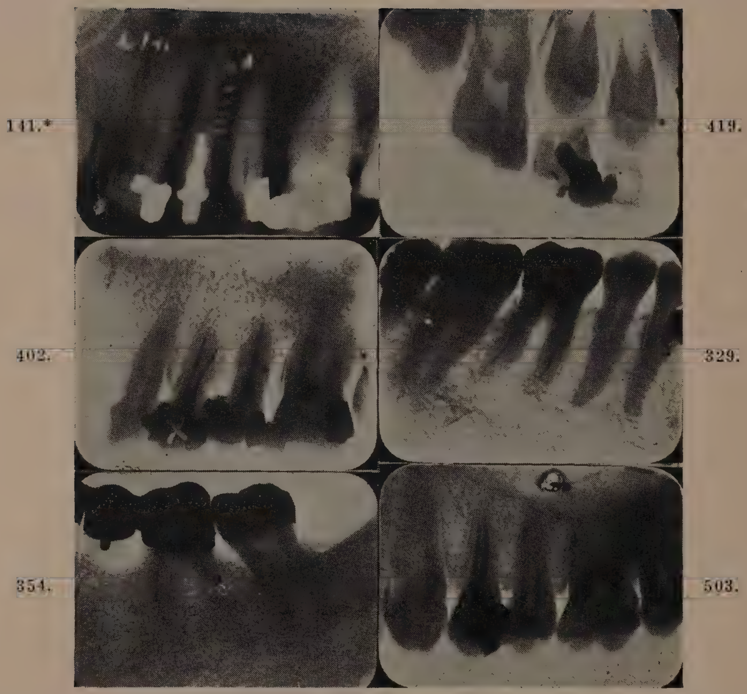


Fig. 418.—Uncovered x-rays as seen in Fig. 1, page 19. Serial numbers correspond.

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*See Figs. 279 to 296 for sections.

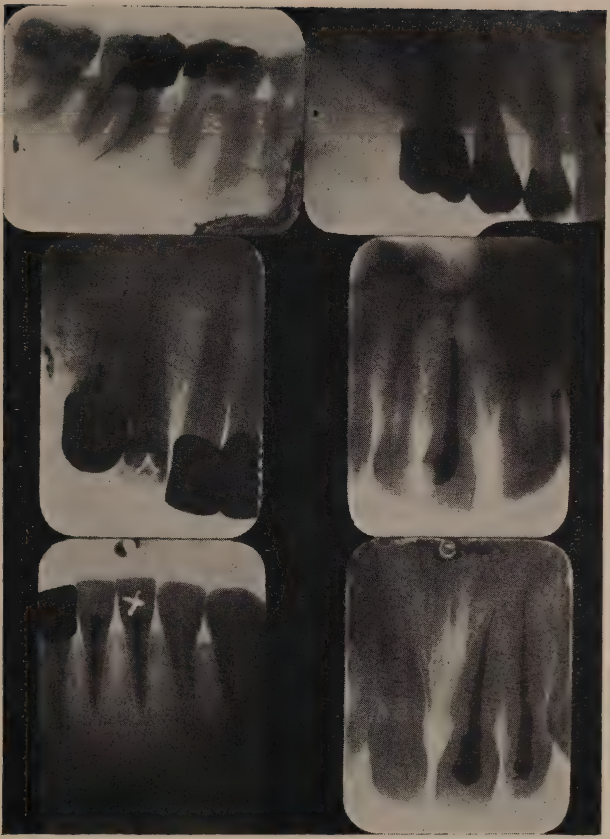

Fig. 419.—Uncovered x-rays as seen in Fig. 2, page 20. Serial numbers correspond.

CHAPTER L

REVIEW OF DENTAL HISTOLOGY*

Dental histology is a study of the minute structures of the teeth and adjacent tissues.

The teeth belong to the dermal skeleton and not to the osseous framework, as they were formerly classified. This is made conclusive from the fact that the first evidence of tooth formation is seen in the oral epithelium. However, not all of the tissues of a tooth are epithelial in origin.

The tissues of which a tooth is made up are enamel, dentine, cementum, and pulp.

The enamel only is derived from the epithelium, while dentine, cementum, and pulp are formed from the mesioblastic layer of tissue.

The dental papilla is that portion of follicle which is enclosed in the epithelial cup. This cup later becomes the enamel organ.

The pulp is what remains of the papilla after the tooth is fully formed.

The cuticula dentis (or Nasmyth's membrane) is a thin covering found on recently erupted teeth, soon worn away on exposed portions, yet persistent for months and even years on protected portions. It is probably derived from the outer tunic of the enamel organ.

The enamel is composed of from 3½ to 6 per cent water and from 94 to 96½ per cent inorganic matter. It is probable that the ''organic matter'' thought to be obtained analytically by ignition is simply water in combination with lime salts.

The chief constituents of enamel are phosphate and carbonate of calcium, being from 90 to 94 per cent.

The structure of enamel is a collection of five- and six-sided rods connected by means of a cementing substance.

The enamel rods are generally found so arranged that their long axis is at right angles to the surface of the dentine from which they arise, particularly so in the middle third of axial surfaces. In the gingival third of these surfaces there is an increasing inclination of the external ends of the enamel rods toward the gingival. The same is true of the incisal or occlusal thirds where the inclination increases as the cutting edge is approached.

The rods are made up of a series of globules placed end to end. Under a powerful microscope they resemble a string of beads. These seem to be joined without the cemental media.

The rods differ in length. While most of the rods extend from the dentine to the surface, being then termed full-length rods, there are many which originate in the body of the enamel between the full-length rods and continue their course to the surface. As the rods are of approximately the same size, the additional rods would seem necessary to compensate for the difference in the surface area of the dentine and enamel.

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*In this chapter are given some of the most important points pertaining to the formation of the teeth and their minute structure as these affect operative procedures. It is not intended that this will answer for a course in dental histology.

In some there will occasionally be seen a rod which begins in the surface of the dentine and falls short of coming to the external surface, this condition being most frequently met with on occlusal surfaces of molars.

The rods vary as to degree of curvature; some are nearly straight, some describe the segment of a circle, while others show a compound curve even to being much contorted. Such enamel is termed "gnarled" and is the more resistant to stress in mastication as well as to the force of instruments in operative procedures. The enamel made up of straight or nearly parallel rods is the more friable and the easier of fracture either from use or under stress of instrumentation.

The diameter of a rod varies through its length, resulting in enlarged sections called varicosities. These enlarged portions of one rod are opposite the enlargements of the rods paralleling it, which condition results in spaces between the constricted portions of the rods. This space is filled with a highly calcified cement substance.

The interprismatic cement is largely composed of calcic material, proved by the fact that it is very susceptible to the action of acids, being more readily dissolved than the rods, as in the process of decay it disappears first to allow the rods to fall apart.

The cleavage of enamel is along the line of the long axis of the enamel rods accomplished by a dissolution of the cemental substance. A few of the rods may be broken crosswise, especially near the point of impact from a blow, but the fracture is never to any great extent at an angle to the direction of the long axis of the rods. When the enamel rods rest upon sound dentine and each is supported laterally by its neighbors, it is capable of resisting a great amount of force, but when either of the above conditions are wanting, they become easily dislodged, a fact of great moment relative to the making of fillings.

The dentine histologically is a highly developed connective tissue, which is nonvascular. It forms the greater bulk of the tooth which it materially resembles in shape. That is to say, if the enamel which covers the coronal portion and the cementum which covers the root portion were removed, there would still remain the general characteristics and form shown in the entire tooth.

The physical structure of dentine is that of a partly calcified organic matrix traversed by a system of tubules, known as the dentinal tubules.

The matrix is seemingly structureless, and composed largely of inorganic matter. As it is physically impossible to remove the contents of the tubules, no exact chemical analysis has as yet been made of the matrix proper.

The chemical composition of dentine as a whole is given as approximately one-fourth organic and three-fourths inorganic, with a varying amount of water up to 12 or 14 per cent.

The principal inorganic substances are phosphate and fluoride of calcium.

The tubules are minute canals, rounded in form, which traverse the dentine for its entire thickness. They leave the walls of the pulp chamber at right angles to its surface. In their course to the surface of the dentine they give off numerous branches, many of which unite with the neighboring tubules. As they approach the surface of the dentine this branching increases and their course becomes more irregular. As the number increases they become more closely packed at the expense of the matrix, for the size of the tubules shows slight variation.

The tubules contain a substance resembling protoplasm which is connected with the odontoblasts. These protoplasmic processes are known as dentinal fibrils.

The dentinal fibrils are the media through which sensation is conveyed to the pulp, yet it has not been demonstrated that they contain nerve filaments.

The dentinal tubules are lined with a particularly indestructible sheath resisting the action of acids; caustic soda and even caries of the teeth does not destroy them.

The odontoblasts are the cells which perform the function of forming the dentine and make up the most external layer of the pulp.

The primary dentine is that which normally exists in a fully formed tooth. When the tooth is fully formed the odontoblasts nearly or quite cease to functionate and again begin their function of dentine building only when sufficiently irritated for a stimulus to result.

Secondary dentine is the term applied to the result of this renewed functionating of the odontoblasts.

Cementum is the external portion of the root of a tooth and acts as a medium of attaching the pericementum and dentine. It resembles bone both anatomically and histologically in many respects. Its greatest point of difference is the absence of the Haversian system. Lacunae and canaliculi are present, however.

The Formation of Cementum.—Cementum is the last of the dental tissues to form, covering the roots of young teeth but thinly. Its growth persists through life, so that the teeth in mature life show a considerable body of cementum, particularly in the apical region.

When this growth is abnormal, due to a stimulating irritant, it is termed hypercementosis.

The cells which build cementum are called cementoblasts.

The tooth pulp is the soft tissue occupying the central portion of a tooth known as the pulp chamber. It is the formative organ of the dentine during the process of development and is the source of nutrition to the dentine during life.

Anatomically it is composed of a very delicate connective tissue, richly supplied with blood vessels and thickly threaded with nerve fibers.

The blood vessels and nerve enter the pulp through the apical foramina, each giving off many branches in their course to the periphery.

The most external cells of the pulp are the odontoblasts, which normally have no sense of touch.

The shape of the pulp as a whole resembles that of the external surface of the tooth and at one stage of development it was nearly as large. But during the formation of dentine it really incases itself.

The process of retraction on the part of the pulp seems to take place more slowly from near the seat of primary calcification, resulting in hornlike processes projecting into the dentine in the direction of the cusp with which each has been associated in developing. As these horns slowly retract they leave what is termed the ''line of retraction of the pulp'' not always vacated, a fact which has to be borne in mind when operating in these localities.

The pericementum (or periodontal membrane) is a fibrous connective tissue investing the root of the tooth. It is a single membrane common to the cementum and alveolar wall, thickest in the apical region, resulting in what is termed the apical space.

The functions of the pericementum are:

First, it is the formative organ of the cementum.

Second, it plays a large part in the retention of the tooth in its socket, aiding it to resist the forces of traction, torsion, and percussion.

The particular **arrangement of the bundles of fibers** found in the pericementum should be noted as they materially differ in their direction.

Arising in the alveolus, some of the fibers pass toward the apex and others toward the gingival margin some distance before being attached to the cementum, while others pass to the right and left at right angles to the long axis of the tooth before being also attached to the cementum.

The former are called longitudinal fibers and are most abundant near the apex of the tooth, while the latter are called circular fibers and increase in number as the gingival margin is approached. At the gingival margin some of the fibers are attached to the gingiva to cause the gum to hug the neck of the tooth.

It will be seen that this arrangement admirably assists the tooth to withstand the strain of stress to which it must frequently be subjected.

At the same time it permits a certain amount of movement, thereby protecting it from the effects of coming in contact with unyielding substances.

Third, it furnishes the tooth with its tactile sense, or the sense of feeling, that its possessor may, through education, detect the substances with which the teeth are brought in contact. This function is very acute at all times, but when the pericementum becomes inflamed this property becomes abnormally developed.

Fourth, the pericementum provides nutrition for the cementum through its abundant vascular supply.

The cellular elements of the pericementum are:

Cementoblasts, persistent in the formation of cementum.

Fibroblasts, for the repair of the fibrous tissues.

Osteoblasts situated on the side next to osseous tissues, whose function is to build bone around the fibers of the pericementum, thus to attach them more strongly to the bony wall.

Osteoclasts, multinucleated giant cells, not always present, but capable of acting upon bone, cementum or dentine, are to be found in great numbers when the dissolution of these tissues is in progress. Epithelial cellular bodies are not infrequently observed in the inner portion of the periodontal membrane. Their function is not known. It is believed by some that they are the remains of the enamel organ.

INDEX*

A

Abraded surfaces, class six, Chapter XXII, 113
  defined, 113
  cause not wholly clear, 113
  object in filling, 113
  occlusal surfaces, 113
  early restoration, 113
  cavity preparation, 113
  major portion of one occlusal surface, 113
  if contact points have been reached, 114
  when wear is general, 114
  with incisal abrasion only, 114
  entire enamel covered, 114
Access, gaining, 59
Aging of comminuted silver-tin alloy, 225
Alleviation and prevention of odontalgia, Chapter II, 23
  cause of first visit, 23
  diagnosis, 23
  symptomatology, 23
  divisions of dental pains, 23
  pulp pains, endodontia, 23
  cold causes pain (active hyperemia), 23
  treatment of pain in active hyperemia, 23
  warmth causes pain (passive hyperemia), 24
  treatment for pain in passive hyperemia, 24
  cold relieves pain (closed putrescence), 24
  treatment for pain in closed putrescence, 24
  pressure of tooth causes pain (active complicated putrescence), 24
  treatment for pain in active complicated putrescence, 24
  pain following tooth extraction, 24
  "dry socket" pain, treatment of, 25
  facial neuralgia, 25
  neuralgia of dental origin, 25
    general treatment of, 25
    local treatment of, 25
    surgical treatment, 26
  rheumatic neuralgia, 26
  pain from dental operations, 26
  general anesthetics, 26
  local anesthetics, 26
  pain of cavity preparation, 26
  summary, 27
Amalgam and cement combination filling, 259
  and silicate combination filling, 261
  die construction, 165
Amalgam filling, Chapter XXXII, 208
  amalgam defined, 208
  properties of amalgam, 208

Amalgam filling—Cont'd
  objections to amalgam, 208
  cavity preparation, 208
  flat seats for filling, 208
  rubber dam, 208
  matrix, 209
  separation, 209
  making mix, 209
  making filling, 210
  trimming amalgam fillings, 211
  removal of matrix, 211
  amalgam should be cut from margin, 211
  passing contact point, 211
  polishing, 211
  expansion of amalgam, 212
  use and abuse of amalgam, 212
  amalgam has other enemies, 213
  zinc to about 0.3 acts as scavenger at time of melting, 213
  conclusions, 216
    dentists should know zinc content of alloy used, 216
    prove alloy, 216
    learn about overmixing, 216
    get timed mechanical mixer, 216
    as each portion is added, 216
    matrix housing, 216
    not touched by finger or hand, 216
    avoid contamination with moisture, 216
    avoid salty moisture contamination, 216
    dry cavity, 216
    when placed in vital young teeth, 216
  new metallographic hypothesis, 217
  metallography of dental amalgams, 217
  contractions and expansions following amalgamation, 218
  typical curve of reaction expansion, 219
  explanation of typical curve, 220
  factors that influence dimensional changes, 221
    how tin in alloy facilitates contraction, 224
    "aging" of comminuted silver-tin alloy, 225
  experimental data illustrating hypothesis, 226
    reaction expansion of tin amalgam, 226
    effects of changing amalgamation variables, 229
    effects of particle size and packing pressure, 235
    effects of temperature during hardening, 247
    precautions in measuring, 247
  correct technic showing microns expansion, 244

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*In addition to alphabetical references and cross references, to aid in study the chapter is outlined in page sequence under the chapter heading which appears in italics.

Amalgam filling—Cont'd
    expansion tests, abused amalgam, 245
    results of correct and abused technic, 250
Amalgamation, contractions and expansions following, 218
  variables, effect of changing, 229
Amputation of pulp, 353
Anatomic mounts, making, 413
Anesthesia for apicoectomy and curettement, 402
  in odontalgia, 26
  pulpectomy with, 329 (*See also* Pulpectomy with anesthesia)
Anesthetics, 26
  and anodynes for treatment of hypersensitive dentine, 54
Angle, incisal, direction of, 100
  restoration, 103
Angles, gingival, 102
Anodynes and anesthetics for treatment of hypersensitive dentine, 54
Apicoectomy and curettement, Chapter XLVII, 402
    definition, 402
    when indicated, 402
    when contraindicated, 402
    cause, 402
    anesthetic, 402
    technic of apicoectomy, 403
    case report, 406
Apicoectomy defined, 329
  following pathology of pulp canals, 388

B

Bacteria in periodontoclasia, 264
Bacterial infection of pulps, 326, 379
Bevel of cavity, 47
Bicuspids and molars, proximal cavities, 80
Brushing, technic of, 38

C

Calculus, 34, 264
Canal filling, 352
    following pulpectomy, 332
Caries as cause of hypersensitive dentine, 50
Carious dentine, removal of remaining, 69
Cast, gold, making, 205
Casting, sprue in relation to, 202
Cavities, class one, pit and fissure, Chapter XV, 72
    location, 72
    predisposing cause, 72
    extension for prevention seldom necessary, 72
    extensive dentinal decay, 72
    decays in occlusal defects, 72
    outline form, 72
    use of chisel, 72
    resistance form, 73
    retention form, 74
    convenience form, 74
    removal of remaining decay, 74
    walls should be flat, 74
    disinfection, 74
    finish of enamel walls, 74
    toilet of cavity, 74
    inlay retention, 74
Cavities, class one, pit and fissure (concluded), Chapter XVI, 75
  large cavities in central fossa of molars, 75
    description, 75
    outline form, 75
    when pulp exposure is feared, 75
    placing rubber dam, 75
    when pulp is exposed, 75
    resistance and retention forms, 75
    flattening of pulpal walls avoided, 77
    convenience form, 77
    convenience point, 77
    finish of enamel walls and toilet, 77
  pit cavities in buccal and lingual surfaces of molars, 77
    description, 77
    outline form, 77
    resistance form, 77
    extension for prevention, 78
    retention form, 78
    finish of enamel walls, 79
  pit cavities in lingual surfaces of upper incisors, 79
    should receive early attention, 79
    instrumentation, 79
    outline form, 79
    incisoaxial line angle, 79
Cavities, class two, proximal cavities in bicuspids and molars, Chapter XVII, 80
  defined, 80
  predisposing cause of decay, 80
  early detection essential, 80
  small class two cavities, 80
  description, 80
  gaining access, 80
    first method, 80
    second method, 81
    third method, 81
    preliminary separation, 81
  outline form, 81
  step may be omitted, 81
  outline of cavity proper, 82
  good rule to follow, 82
  extensions gingivally, 83
  care at axiogingival angles, 83
  gingival outline, 83
  forming the step, 83
  area included, 84
  avoiding angles in outline, 84
  resistance and retention forms, 84
  buccal and lingual walls, 84
  axial wall, 84
  pulpal wall, 84
  line angles, 84
  convenience form, 84
  using inlays, 84
  finish of enamel walls, 85
  toilet of cavity, 85
Cavities, class two, proximal cavities endangering pulp, Chapter XVIII, 86
  description, 86
  danger of pulp exposure, 86
  outline form, 86
  extension for prevention, 86
  gingival outline, 86
  occlusal outline, 86

Cavities, class two—Cont'd
  removal of remaining decay, 86
    technic, 87
  resistance and retention forms, 88
  gingival wall, 88
  convenience form, 88
  pulp protection, 88
  finish of enamel walls, 88
  toilet of cavity, 88
  large proximal cavities in nonvital teeth, 88
  outline form, with molars, 88
    with bicuspids, 88
    mesiodistoclusal cavities, 88
    cases of extreme frailty, 89
  retention form is completed, 90
  screw-post anchorage, 90
  sectional fillings, 90
  convenience form, 91
  neglected access form, 91
  toilet of cavity, 91
  overdesiccation, 91
Cavities, class three, proximal cavities in incisors and cuspids not involving angle, Chapter XIX, 92
  defined, 92
  general form, 92
  location of primary decay, 92
  opening cavity, 92
  gaining access, 92
  outline form, 92
  gingival outline, 93
  incisal outline, 93
  labial outline, 93
  additional extension, 94
  lingual outline, 94
  resistance form, 94
  retention form, 94
  incisal line angle, 95
  other point angles, 95
  line angles, 96
  axiolabial line angle, 96
  axiolingual line angle, 96
  gingivolabial and gingivolingual line angles, 96
  gingival wall, 96
  axial wall, 96
  labial and lingual walls, 96
  convenience form, 96
  removal of remaining decay, 96
  finish of enamel walls, 96
  in pulpless cases, 96
Cavities, class four, proximal cavities in incisors involving angle, Chapter XX, 97
  defined, 97
  demanding angle restoration, 97
  difference between mesial and distal surfaces, 97
  plans of angle restoration, 97
  retention form in fillings, 97
  direction of incisal angle, 100
  gingival angles, 102
  first plan of angle restoration, 103
    gingival point angles, 104
    to assist incisal angle, 104
    labial outline, 104
    rule for labial outlines, 104
Cavities, class four, first plan—Cont'd
    necessity for curving to angle, 104
    arrangement of enamel rods at incisal edge, 104
    incisal outline, 104
    lingual outline, 105
  second plan of angle restoration, 105
    incisal edge, 105
    depth of step, 105
    technic of cutting, 105
    point angle in step portion, 105
  third plan of angle restoration, 106
    this plan indicated, 106
    labial outline, 106
  fourth plan of angle restoration, 107
    distal of superior cuspids, 108
    access is easy, 109
    outline form, 109
    step, 109
    axial walls, 109
    lingual axial wall, 109
    convenience form, 109
Cavities, class five, in gingival third, Chapter XXI, 110
  difference, 110
  prevention, 110
  tendency to spread in enamel, 110
  gingival outline, 110
  occlusal or incisal outline, 110
  retention form, 110
  in large buccal decay, 110
  if pulp canals are involved, 111
  if gold is to be used, 112
  with labial cavities, 112
Cavities, class six, abraded surfaces, occlusal and incisal, Chapter XXII, 113
Cavity nomenclature, Chapter VI, 43
  cavity nomenclature is necessary, 43
  cavities derive names from surfaces of teeth, 43
  simple cavity, 43
  complex cavity, 43
  complex cavities named, 43
  axial surface cavity, 43
  proximal cavities, 43
  cavities divided as to origin, pit and smooth surface, 43
  cavities divided according to line of treatment, 43
  classes, 43
  outside walls of cavity, 43
  pulpal wall, 43
  axial wall, 44
  gingival wall, 44
  both gingival and subpulpal walls may be present, 44
  inside walls, 45
  base of cavity, 45
  line angle, 45
  point angle, 45
  line angles in simple cavity, 46
  enamel margins defined, 46
  external enamel line defined, 47
  cavosurface angle defined, 47
  base of cavosurface angle, 47
  marginal bevel defined, 47
  beveling is necessary, 47
  bevel angle defined, 48

- *Cavity nomenclature*—Cont'd
  - horizontal plane, 49
  - mesiodistal plane, 49
  - buccolingual plane, 49
  - summary, 49
- Cavity outline form, 61
- *Cavity preparation for gold inlay, Chapter XXX, 183*
  - inlay defined, 183
  - materials, 183
  - indications for gold inlay, 183
  - gold inlay not indicated, 183
  - cavity preparation, 183
  - slight changes in order, 183
  - change of position, 183
  - order of procedure for inlays, 184
  - gaining access, 184
  - resistance form, 184
  - convenience form, 184
  - removal of decay, 184
  - finishing of enamel walls, 184
  - more beveling at cavosurface angle, 184
  - toilet of cavity, 185
  - after pattern has been formed, 185
  - line of approach, 185
  - preparation of class one cavities, 185
    - outline form, 185
    - resistance form, 185
    - major portion of retention form, 185
  - preparation of class two cavities, 187
    - access, 187
    - complete preliminary separation, 187
    - outline form, 187
    - resistance form, 187
    - retention form, 187
    - in pulpless cases, 188
    - finishing of enamel walls, 188
  - preparation of class three cavities, 188
    - access, 188
    - outline, 188
    - gingival wall, 189
  - preparation of class four cavities, 189
    - plans one and three for pulpless teeth, 189
    - resistance form, 189
    - retention form, 189
    - enamel walls, 192
  - preparation of class five cavities (*See* Fig. 118), 194
    - occlusal wall, 194
  - preparation of class six cavities, 194
    - in pulpless cases, 194
- *Cavity preparation (general considerations), Chapter VIII, 58*
- Cavity preparation, pain in, 26
  - toilet of, 70
- Cement and amalgam combination filling, 259
  - and gold combination filling, 258
- *Cements in filling teeth, Chapter XXXIII, 251*
  - varieties, 251
  - cavity preparation, 251
  - oxyphosphate of zinc, 251
    - chief fault of, 251
  - oxychloride of zinc, 251
  - oxide of zinc with oil of cloves, 251
  - oxyphosphate of copper, 251
- *Cements in filling teeth*—Cont'd
  - manipulation of oxyphosphate of zinc cement, 251
  - plan of spatulating, 252
  - research with cements, 252
    - temperature control, 252
    - tests for adhesion, 256
  - conclusions, 257
- Ceramic technic for fillings and jacket crowns, 159
- Children's teeth, endodontia for, 408
  - pulpectomy, partial, 353
- Chloroform for hypersensitive dentine, 55
- Christian Science patients, 380
- Classification of cases with pulp involvement, 323
- Cleanliness, oral, in preventive dentistry, 28
- *Cohesive gold in making of filling, Chapter XXIV, 122*
  - physical properties, 122
  - objectionable qualities, 122
  - welding of gold, cold, 122
  - injury by contamination, 122
  - to protect surface of gold, 122
  - annealing gold, 123
  - degree of heat, 123
  - methods of annealing, 123
  - specific gravity, 123
  - cohesion of pure gold, 123
  - serrated plugger points, 123
  - bridging, cause, 124
  - same-sized serrations, 124
  - avoid rotating plugger in fingers, 124
  - size of plugger point, 124
  - preparation of foil, 125
  - application of foil, 125
  - forces used in condensing, 125
  - hand pressure alone, 126
  - mallet force alone, 126
  - rule for use of varied force, 126
  - hand mallet, 126
  - automatic mallet, 126
  - power mallet, 126
- *Cohesive gold in making of fillings by classes, Chapter XXV, 127*
  - class one cavities, 127
    - starting filling, 127
    - occlusal cavities, 127
    - buccal cavities, 127
    - with long irregular outline, 127
  - class two cavities, 127
    - beginning filling, 127
    - three plans of starting class two, 128
    - order of stepping plugger, 128
    - when gold extends beyond contour, 128
    - progress of filling, 128
    - covering pulpal wall, 129
    - contact point, 129
    - position of contact point, 129
    - moving contact point flush to occlusal, 129
    - last portions of gold, 130
    - filling with matrix in position, 130
    - use of separator, 131
  - class three cavities, 131
    - starting gold, 131
    - filling incisal angle, 132
    - lingual approach, 132

Cohesive gold—Cont'd
    class four cavities, 132
        starting filling, 132
        final portions of gold, 132
        layers of gold, 133
    class five cavities, 133
    class six cavities, 133
Combination fillings, Chapter XXXIV, 258
    defined, 258
    objects of combining, 258
    single materials used as fillings, 258
    gold and tin, 258
        benefits derived, 258
    gold and cement, 258
        two methods of combining, 258
        when indicated, 259
    gold and platinum, 259
    cohesive and noncohesive gold, 259
    cement and amalgam, 259
        benefits, 259
        when indicated, 259
    cement and porcelain, 259
    silicate cement and fused porcelain, 259
    silicate and gold, 259
    silicate and amalgam, 261
    silicate as applied to prosthetic work, 261
Contractions following amalgamations, 218
Convenience form, Chapter XIII, 68
Copper in cement fillings, 251
Correcting pulp canal surgery, Chapter XLV, 386
    selection of cases, 386
    pathology, 386
    partial canal fillings, 386
    multirooted teeth, 386
    instruments in canal, 387
    technic of removing previous canal fillings, 387
    removing gutta-percha canal fillings, 387
    broken broaches in pulp canals, 387
    apicoectomy, 388
Curettement and apicoectomy, 402
Curve of reaction expansion of amalgam, 219

D

Deciduous teeth, endodontia for, 408
    pulpectomy, partial, 357
Dental histology review, Chapter L, 416
    definition, 416
    teeth belong to dermal skeleton, 416
    tooth tissues, 416
    enamel derived, 416
    dental papilla, 416
    pulp, 416
    cuticula dentis, 416
    enamel, 416
        chief constituents, 416
        structure, 416
    enamel rods, 416
        made up of, 416
        differ in length, 416
        vary as to degree of curvature, 417
        diameter, 417
        interprismatic cement, 417
        cleavage of enamel, 417
Dental histology—Cont'd
    dentine, 417
        physical structure, 417
        matrix, 417
        chemical composition, 417
        principal inorganic substances, 418
        tubules, 418
        fibrils, 418
        lining of tubules, 418
        odontoblasts, 418
        primary dentine, 418
        secondary dentine, 418
    cementum, 418
        formation, 418
        cells, 418
    tooth pulp, 418
        anatomic composition, 418
        most external cells, 419
        shape, 419
        process of retraction, 419
    pericementum, 419
        function, 419
        arrangement of fibers, 419
        cementoblasts, 420
        fibroblasts, 420
        osteoblasts, 420
        osteoclasts, 420
Dentine, hypersensitive, treatment of, 50
Dentistry, preventive, 28
Devitalization, pulp, 330
Diagnosis and examination, 17 (*See also* Examination and diagnosis)
Diet in preventive dentistry, 28
Dimensional changes in amalgam fillings, 221
Drugless management of putrescent pulp canals, Chapter XLIV, 379
    too much dependence on strong drugs, 379
    in complicated putrescence, 379
    technic, 379
    streptococcus viridans, 379
    other bacteria, 379
    sterilization, 380
    Christian Science patients or dentists, 380
    pulpodontia (Dr. Albert), 380
        record of treatment, 380
        selection of armamentarium, 381
        procedure in treatment, 382
    hot water or air not used in pulpectomy, 385
"Dry socket" pain, 25

E

Enamel walls, finishing, 69
Endodontia, Chapter XXXVI, 293
    problem, 293
    objective, 293
    correct diagnosis, 293
    ability to diagnose, 293
    pain, 293
    comprehensive diagnosis, 293
    radiograph, 293
    electrical tests and thermal changes, 294
    percussion or percussion note, 294
    extent of osseous or cemental absorption, 294

Endodontia—Cont'd
  dental infection, 294
  teeth without visible absorption of bone, 294
  diplostreptococcus, 294
  objective symptoms, 294
  patients should be classified as to susceptibility, 294
  further diagnosis, 295
  tooth root anatomy, 295
  vital tooth defined, 321
  selection of patients, 322
  selection of teeth, 322
  fees, 322
  classification, 323
Endodontia for children's deciduous and permanent teeth, Chapter XLVIII, 408
  pulps of deciduous teeth, 408
  vital pulps, 408
  technic, 408
  coronal portion involved, 409
  putrescent deciduous canals, 409
Endodontia, prognosis, 410
Examination and diagnosis, Chapter I, 17
  complete examination early, 17
  pit and fissure cavities, 17
  destructive caries, 17
  equipment, 17
  dental chair, 17
  office and personal linen, 17
  instruments required, 17
  mouth mirror, 17
  explorer, 17
  cotton pliers, 17
  waxed floss silk, 17
  chip-blower, 18
  water syringe, 18
  mechanical separator, 18
  electric mouth lamp, 18
  electric current, 18
  x-ray equipment, 18
  charts, 18
  first requests of patient, 18
  following complete examination, 18
  legal liability, 19
  diagnosis, 19
  before dismissing subject of diagnosis, 20
  summary, 22
Exclusion of moisture, Chapter XXIII, 115
  methods of securing dryness, 115
    rubber dam, 115
    absorbents, 115
    saliva ejector, 115
  objections to rubber dam, 115
  neglect of dryness, 115
  importance of dryness, 115
  materials and dryness, 115
  for sterilization and prevention of infection, 115
  when treating pulp canals, 116
  required for cavity walls, 116
  better view of cavity, 116
  extent of decalcification, 116
  to lessen pain of cavity excavation, 116
  when using caustic drugs, 117
  as timesaver, 117
Exclusion of moisture—Cont'd
  rubber dam best means, 117
    size and shape, 117
    holes to receive teeth, 117
    distance between holes, 117
    location of holes, 118
    number of teeth isolated, 118
    with anterior teeth, 118
    with bicuspids and molars, 118
    position of clamp, 118
    placing the dam, 118
    occlusal side of dam defined, 118
    gingival side of dam defined, 118
    method of applying dam, 118
    with anterior teeth, 118
    with posterior teeth, 119
    to prevent leakage around teeth, 119
  use of ligature, 119
    caution, 119
    economy, 119
    length of loose ends, 119
    most popular knot, 119
    "Wedelstaedt tie," 119
    removal, 120
    with amalgam fillings, 120
    good rule to remember, 120
  selection of clamp, 120
    method of applying, 120
    in using cervical clamps, 120
  removal of rubber dam, 120
  use of absorbents, 121
Expansion following amalgamation, 218
Extension for prevention, 62, 66, 72, 78, 83, 154
Extraction, pain following, 24

F

Fauchard's disease, 262
Fees, 322
Filling, fused porcelain, 154
Filling of pulp canals (mechanical), Chapter XLVI, 389
  why necessary, 389
  when canal is ready, 389
  perfect pulp canal filling, 389
  requirements of material, 389
  objective point, 389
  small canals, 389
  means of cleansing and vacating, 389
    best accomplished, 389
    when root is bent on long axis, 389
  pulp canal fillings by classes, 391
  ideal pulp canal, 392
  care of instruments, 392
  materials for pulp canal fillings, 393
  technic of filling pulp canals, 394
    with gutta-percha, 394
    first mechanical procedure, 395
    fluidity as part of canal filling, 395
    silver-center canal points, 395
    filling canals beyond point of instrumentation, 395
    use of paste in inaccessible part of canal, 395
  overfilled root, 396
  canal fillings short of foramen, 397
  perforated roots, 399

- *Filling of pulp canals*—Cont'd
  - root amputation, 400
  - management of complicated multirooted teeth, 400
- Filling, silicate, 136
  - teeth, cements in, 251
- Fillings, combination, 258
  - gold, finishing, 134
- *Finishing enamel walls, Chapter XIV, 69*
  - defined, 69
  - moisture not permitted, 69
  - cavosurface angle, 70
  - plane of enamel wall, 70
  - how accomplished, 70
  - marginal bevel, 70
  - depth of marginal bevel, 70
- *Finishing gold fillings, Chapter XXVI, 134*
  - secondary condensation, 134
  - burnishing, 134
  - following secondary condensation, 134
  - use of saw, 134
  - excess at gingival, 134
  - finishing knife, 135
  - coarse abrasives, 135
  - finishing strips in proximal, 135
  - when entire cavity outline has been exposed, 135
- Fistula, acute complicated putrescence with, 372
  - chronic, 378
- Floss silk, use of, in cleaning teeth, 38
- Fluorine in preventive dentistry, 29
- Form, resistance, 65
  - retention, 67
- Fractured jacket crowns, repair of, 181
- *Fused porcelain filling, cavity preparation, Chapter XXVIII, 154*
  - cavity preparation, 154
  - access form, 154
  - outline form, 154
  - extension for prevention, 154
  - resistance form, 154
  - retention form, 154
  - convenience form, 154
  - finish of enamel walls, 154
  - toilet of cavity, 154
  - second toilet of cavity, 155
  - preparation of cavities, class one, 155
    - avoid exact circle, 155
    - axial wall, 155
    - surrounding walls, 155
  - cavities, class two, 155
  - cavities, class three, 155
    - labial approach, 155
    - lingual approach, 156
    - proximal approach, 156
  - cavities, class four, plan one, 156
    - proximal approach may be used, 156
    - break cement on incisal edge, 156
  - cavities, class four, plan two, 156
  - cavities, class four, plan three, 156
  - cavities, class four, plan four, 157
    - treble step, 157
  - cavities, class five, 157
    - outline form, 157
    - restoration of portion of incisal edge, 157
    - restoration of entire incisal edge, 158
- *Fused porcelain filling*—Cont'd
  - retention, 158
    - in pulpless anterior teeth, 158
  - treatment of teeth with malformed enamel, 158
- *Fused porcelain filling, ceramic technic for fillings and jacket crowns, Chapter XXIX, 159*
  - discussion of dental porcelain, 159
  - investment method—without platinum matrix, 159
    - physical properties compared, 160
    - manipulation compared, 160
    - method of procedure, 160
    - when investment material has set, 160
    - as moisture leaves porcelain, 162
    - if porcelain has been properly condensed, 162
    - this direct method is quicker, 162
    - die and matrix method has practical advantages, 162
    - for gingival margin cavities, 162
    - posterior gingival margin cavities, 163
  - die and matrix method, impressions, 163
    - two-surface cavity impressions, 164
    - anterior corner restorations, 165
    - posterior two-surface cavities, 165
  - amalgam die construction, simple, 165
    - when amalgam has set, 165
  - amalgam die construction, tube impressions, 165
  - simple surface cavities, adaptation of matrix, 166
    - choice of foil thickness, 166
    - application of porcelain, 168
  - compound cavities, adaptation of matrix, 168
    - bring excess foil together, 168
    - after burnishing, reswage and remove matrix, 170
    - application of porcelain, 170
    - adding second bake of porcelain, 170
    - replace matrix on die and add porcelain again, 170
    - as used in matrix technic, 170
  - impressions, dies and models, 172
    - ordinary wax bite, 172
    - contact teeth amalgam packed, 172
  - matrix construction, 172
    - ''tinner's joints'' in bicuspid matrices, 174
    - on incisal edges, 174
    - application of porcelain, 174
    - by other method, bake shoulders first, 175
    - swaging on amalgam die, 175
    - first bake to 100 degrees below glazing, 175
    - where tooth is broken down, 175
  - porcelain carving, 178
    - average index of shrinkage, 178
    - various methods of condensing, 178
    - bubbles and porosity, 179
    - jacket crown carving, 179
    - methods of construction, 179
  - shade selection, 180
    - formulas made to match shade-guides, 180

Fused porcelain filling—Cont'd
  discussion of glazing, 181
    thermochemical action, 181
    as time element is increased, 181
  repair of jacket crown, 181
  suggestion, 182

G

Gaining access, Chapter IX, 59
  defined, 59
  sufficient access is important, 59
  access to tooth, 59
  surgical access, 59
  access as related to restoration of proximal space, 59
  restoration of tooth form, 60
  proper contact point, 60
  saving of tooth substance, 60
  methods of separation, 60
  preliminary separation, 60
  immediate separation, 60
  avoid gum injuries, 60
  soreness resulting from tooth separation, 60
Gingivitis, 262
Glycerin mounts, making, 413
Gold and cement combination filling, 258
  and platinum filling, 259
  and tin combination filling, 258
  cohesive, in making filling, 122, 127 (*See also* Cohesive gold in making of filling)
  fillings, finishing, 134
  inlay, cavity preparation for, 183 (*See also* Cavity preparation for gold inlay)
Gold inlay, making and setting, Chapter XXXI, 195
  discussion, 195
  object of inlay, 195
  history, 195
  method using pattern entirely of wax, 195
    filling of undercuts, 196
  making of pattern, direct method, 196
    ideal conditions, 197
  placing sprue wire, 197
  giving wax pattern retention form, 197
  method of using wax pattern, pin attached, 198
    placing pin, 198
    stellite pins, 198
  method of using pure gold matrix with pin soldered on, 198
  making wax contour, 199
  to restore occlusal and incisal surfaces, 199
  method of sweating contour, 200
  method of using sponge gold as pattern, 200
    making pattern, 200
    investing, 200
    saturating model, 201
  investing patterns, 201
    length and gauge of sprue, 202
    burning out wax, 204
  gold carat for inlays, 205

Gold inlay, making and setting—Cont'd
    making cast, 205
    chilling cast, 205
    results of technic, 205
    preparing inlay for setting, 206
    setting inlay, 206
  small inlay carrier, 207
  other methods, 207
    fit obtainable, 207
Granuloma, 374
Gutta-percha, filling canals with, 394

H

Histology, dental, review, 416
  of pulp, 335
Hydrogen dioxide in removal of sordes, 38
Hypersensitive dentine, Chapter VII, 50
  defined, 50
  normal dentine, 50
  sensations are conveyed to pulp, 50
  contents of tubules, 50
  direct cause of sensitive dentine, 50
  rapidity of caries, 50
  most sensitive part of carious tooth, 50
  mechanical abrasion, 50
  exposure of cementum, 50
  abnormal oral secretions, 50
  where hypersensitive dentine is found, 51
  varying temperaments of patients, 51
    highly wrought, nervous temperament, 51
    irresponsible individuals, 51
    naturally cowardly patient, 51
    patient who simulates pain, 52
  agents for relief of sensitive dentine classified, 52
  physical agents, 53
    desiccation, 53
    continuous stream of cold air, 53
    heat and cold when moist, 53
    application of cold, 53
    primary pain lessened, 53
    electric current, 53
  destroying agents, 54
    caution in their use, 54
    zinc chloride, 54
    caustic potassa and phenol, 54
    silver nitrate, 54
  local anesthetics and anodynes, 54
    novocain stands first, 54
    slow absorption method, 54
    pressure anesthesia, 55
    high pressure syringe, 55
    phenol, 55
    oil of cloves, 55
    oil of cloves and phenol combined, 55
  agents administered through general system, 55
    potassium bromide, 55
    nitrous oxide, 55
    chloroform slowly administered, 55
    rapid breathing, 56
  mechanical conditions, 56
    cutting should be done at right angle, 57
  novocain, 57
  cold air (Dr. Carpenter's method), 57

I

Incisal surfaces, abraded, 113
Incisors, pit cavities in lingual surfaces of upper, 79
Inlays, gold, 195
Instrument nomenclature, Chapter V, 40
  dental instrument defined, 40
  how named, 40
  order, 40
  suborder, 40
  class name, 40
  subclass name, 40
  rights and lefts, 40
  excavator, 40
  chisel, 40
    edge, 40
    use of, 40
    subclasses, 40
  hoe, 40
    subclasses, 41
  hatchet, 41
    subclasses, 41
  gingival marginal trimmer, 41
  spoon, 41
    use of, 41
  angles, 41
    contra-angles, 41
    binangles and triple-angles, 41
  formula names, 41
  plugger, 41
  dental engine, 41
  engine bur, 42
  sharpening of instruments, 42
Instruments, care of, 392
  for pulp canal work, 329
Investing wax patterns, 200

J

Jacket crown carving, 179
  ceramic technic for, 159
  repair of fractured, 181

L

Laboratory technic for making anatomic mounts, 413
  for preparing sections, 348

M

Mallet method of filling cavity, 145
Malletor, 149
Mallets for gold fillings, 126
Massage of gums, 38, 292
Matrix for amalgam fillings, 209
  for porcelain fillings, 163
Mechanical filling of pulp canals, 389
Medication, canal, 362
Metallography of dental amalgams, 217
Moisture, exclusion of, 115
Molars, central fossa, large cavities in, 75
  pit cavities in buccal and lingual surfaces, 77
Mounts, anatomic, making, 413
Mouth, prophylactic treatment of, 34
Multirooted teeth, pulp canal filling of, 400

N

Neuralgia of dental origin, 25
Nomenclature, cavity, 43
  instrument, 40
Nonvital teeth, large proximal cavities in, 88
Novocain as remedy for hypersensitive dentine, 54

O

Occlusal defects, 72
  surfaces, abraded, 113
Odontalgia, alleviation and prevention of, 23
  (*See also* Alleviation and prevention of odontalgia)
Osmosis in endodontia, 411
Outline form, Chapter X, 61
  definition, 61
  rules, 61
    1. extend to sound enamel, 61
    2. obtain full-length rods, 61
    3. self-cleansing margins, 61
    4. in relation to developmental grooves, 61
    5. fissures and sulcate grooves, 61
    6. enamel eminences, 61
    7. avoid angles in outline, 61
    8. outline in embrasures, 61
    9. enamel margins, 61
    10. extension for prevention, 62
  dangers of increased cavity outline, 64

P

Pain, dental, 23
  in hypersensitive dentine, 53
Partial pulpectomy, intentional, Chapter XL, 353
  in permanent teeth of children, 353
    when indicated, 353
    caused by early decay, 353
    partially developed first molars, 353
    single-rooted, undeveloped teeth, 354
  in deciduous teeth of children, 357
    technic, 357
Partial pulpectomy, unavoidable or accidental, Chapter XXXIX, 334
  definition, 334
  requisites for pulp repair, 334, 346
  pathology, 335
  histology, 335
  independent action as to roots, 341
  diagnosis, 342
  operation of choice, 344
  laboratory technic for preparing sections, 348
  canal filling following, 352
Pattern of wax for gold inlay, 195
Percussion test, 368
Perforated roots, 399
Periodontoclasia, Chapter XXXV, 262
  definition, 262
  limitations, 262
  etiology, 262
    local causes, 262
    traumatic causes, 262
  overuse, 262
  disuse, 263
  faulty occlusion, 263

- *Periodontoclasia*—Cont'd
  - subgingival decay, 263
  - chemicals as primary cause, 263
  - mechanical irritation, 263
  - general cause, 263
  - treatment, 263
  - bacteria encountered, 264
  - local treatment, 264
  - calculus, 264
  - pockets, 264
  - general treatment, 285
    - not in field of dental practice, 286
    - mechanical procedures, 292
  - summary, 292
- Phenol as remedy for hypersensitive dentine, 55
- Pit and fissure cavities, class one, 72
  - class two, 75
- Platinum and gold combination filling, 259
- Pockets in periodontoclasia, 264
- Porcelain and cement combination filling, 259
  - carving, 178
  - fillings, fused, 154
    - ceramic technic for fillings and jacket crowns, 159
  - synthetic, 136
- Preparation, cavity, for gold inlays, 183
- Pressure anesthesia, 330
- Prevention of odontalgia, 23
- *Preventive dentistry, Chapter III, 28*
  - diet, 28
  - oral cleanliness, 28
  - frequent brushing, 28
  - gingival irritants, 28
  - radiographic examination, 29
  - periodic visits to dentist, 29
  - fluorine, 29
    - method of supplying (Dr. Branson), 29
    - topical application, 32
    - use of fluorine, 32
  - summary, 33
- *Prognosis in endodontia, Chapter XLIX, 410*
  - vital pulps, 410
  - young teeth, 410
  - adult teeth, 410
  - use of arsenic, 410
  - putrescent cases, 410
  - dentocemental junction, 410
  - toxic substances, 411
  - osmosis plays a valuable part, 411
  - vital tooth defined, 411
  - technic of making anatomic mounts, 413
- *Prophylactic treatment of mouth, Chapter IV, 34*
  - importance of, 34
  - lack of hygienic conditions about teeth, 34
  - subdental tissues, 34
  - kind of deposits upon teeth, 34
  - composition of salivary calculus, 34
  - lime salts held in solution, 34
  - reasons for precipitation, 34
  - time of deposits, 35
  - kind of food, 35
  - habits of patient, 35
- *Prophylactic treatment*—Cont'd
  - mouths most subject to deposit, 35
  - prevention of salivary deposits, 35
  - serumal calculus, 36
    - where deposited, 36
    - appearance of, 36
    - also found, 36
    - bulk is small, 36
  - stains upon teeth, 36
    - green, 36
    - color due to bacteria, 36
    - injury to tooth substance, 36
    - reason for presence, 36
  - sordes, 36
    - neglect in removal, 36
  - removal of salivary calculus, 36
    - by push-cut method, 36
    - by pull-cut method, 37
    - which teeth to scale first, 37
    - proximal surfaces scaled, 37
  - removal of serumal calculus, 37
  - calculus distinguished by touch, 37
  - surface of roots, 37
  - removal of green stain, 37
  - removal of sordes, 38
  - toothbrush, 38
  - hydrogen dioxide to remove sordes, 38
  - massage of gums, 38
  - instructions to patients, 38
  - technic of proper brushing, 38
  - use of floss silk, 38
  - toothpicks, 39
  - summary, 39
- Prosthetic work, silicate as applied to, 261
- *Protection of vital pulp, Chapter XXXVII, 324*
  - normal pulp, 324
  - when robbed of normal covering, 324
  - chief idiosyncrasy, 324
  - recuperative powers, 324
  - protection, 324
    - indications for, 324
  - age of patient, 324
  - with large loss of dentine, 325
  - location of cavity, 325
  - location of tooth, 325
  - length of time exposed, 325
  - stage of hyperemia, 325
  - symptoms of active hyperemia, 325
  - pulps infected with bacteria, 326
  - general health of patient, 326
    - particularly plethoric patients, 326
  - deep-seated cavities, 326
  - requirements of materials, 326
  - four distinct classifications, 326
    - first class, treatment, 327
    - second class, treatment, 327
    - third class, treatment, 327
    - fourth class, treatment, 328
  - pulp preservers, 328
  - gutta-percha as covering, 328
  - sulfate of zinc pulp capping, 328
  - no pulp should be exposed to its enemies, 328
- Proximal cavities endangering pulp, 86
  - in bicuspids and molars, 80 (*See also* Cavities, class two)

Proximal cavities—Cont'd
  in incisors and cuspids involving angle, 97 (*See also* Cavities, class four)
  in incisors and cuspids not involving angle, 92 (*See also* Cavities class two)
Pulp canal surgery, correcting previous, 386
  canals, filling of, materials for, 393
      mechanical, 389
    putrescent, drugless management of, 379
  pains, 23
  proximal cavities endangering, 86
Pulp putrescence, complicated, acute, with and without fistula, Chapter XLII, 368
    acute form, 368
    percussion test, 368
    in mild cases, 368
    radiograph in one or more angles, 368
    after gaining complete access, 368
    technic of first treatment, 369
    second visit, 369
    in severe active cases without fistula, 370
    in acute complicated putrescence, 370
    radiograph, 370
    acute complicated putrescence with fistula, 372
      first visit, 372
      second sitting, 372
    technic of filling canal, 372
Pulp putrescence, complicated, chronic, with and without fistula, Chapter XLIII, 373
    diagnosis, treatment, and prognosis, 373
    sequelae, 373
    steps in diagnosing chronic infections, 373
    radiographic indications, 373
    treatment of chronic cases, 374
    granuloma, 374
    radiographic diagnosis, 376
    technic, first treatment, 376
      second treatment, 376
      other treatments, 377
    chronic fistula, 378
    with fistula, acute or chronic, 378
    prognosis, 378
    drugs used, 378
Pulp putrescence, simple, Chapter XLI, 360
    clinical divisions, 360
    twenty years more of research, 360
    putrescence defined, 360
    cooperation of physician and dentist, 361
    divisions and diagnosis, 361
    treatment of simple open putrescence, 362
      early canal medication, 362
      second treatment, 363
      sudden shift to complicated case, 363
      last treatment, 364
    simple closed putrescence, 365
      symptoms of, 365
      treatment for, 365
    canal filling following simple putrescence, 365
    radiograph repeatedly, 366
Pulp repair, 334, 346
  vital, protection of, 324 (*See also* Protection of vital pulp)
Pulpectomy, partial, intentional, 353 (*See also* Partial pulpectomy, intentional)
    unavoidable, accidental, 334 (*See also* Partial pulpectomy, unavoidable)
Pulpectomy with anesthesia, Chapter XXXVIII, 329
    terminology, 329
    pulpotomy, 329
    pulpectomy, 329
    partial pulpectomy, 329
    apicoectomy, 329
    instruments, 329
      list of, 329
    pulp devitalization, 330
    pulp anesthesia, 330
    technic for pulpectomy, 330
    pressure anesthesia, 330
    canal filling following pulpectomy, 332
Putrescence, pulp, acute, 368
    chronic, 373
    simple, 360
Putrescent pulp canals, drugless management of, 379
Pyorrhea alveolaris, 262

R

Radiograph, 29, 293, 330, 362, 366, 368, 370, 373, 376
Removal of remaining carious dentine, Chapter XIV, 69
    definition, 69
    in large decayed areas, 69
    in large approximate cavities, 69
    technic, 69
    where exposed pulp is expected, 69
Resistance form, Chapter XI, 65
    definition, 65
    involves consideration, 65
    importance, 65
    force to provide for, 65
    weakened enamel walls, 65
    stress from within, 65
    weakened walls sometimes allowed to remain, 65
    flat seats for fillings, 65
    in proximoclusal cavities, 65
    step is part of resistance form, 65
    extension of margins, 66
    properties of filling materials considered, 66
Retention form, Chapter XII, 67
    definition, 67
    partially provided for in resistance form, 67
    maximum retention form, 67
    flat seats for all fillings, 67
    acute angles required, 67
    little resistance in enamel, 67
Rheumatic neuralgia, 26
Riggs' disease, 262
Root amputation, 400
Roots, perforated, 399
Rubber dam in amalgam filling, 208
    leaks in, 71

S

Salivary calculus, 34
  deposits, prevention of, 35
Scaling teeth, 37
Seats for fillings, flat, 65, 67
Separation, in cavity preparation for gold inlays, 187
  methods of, 60
Shade selection in porcelain fillings, 180
Silicate and amalgam combination filling, 261
  and gold combination filling, 259
Silicate filling, Chapter XXVII, 136
    definition, 136
    composition, 136
      of powders, 136
      of liquids, 136
    first experience with, 136
    confusion has resulted, 136
    similarity of formulas, 137
    fundamental facts, 137
    when silicates are tamped to place, 137
    dates of introduction, 137
    research on silicates, 137
    varied humidity, 138
    summary of findings, 138
    increased powder content, 138
    mixing time, 138
    rate of powder incorporation, 138
    exposure of liquid to air, 138
    effect of temperature on setting time, 138
      of moisture on filling, 138
      of premature exposure to saliva, 139
      of contact with air during hardening, 139
    solubility of silicate, 139
    acidity of silicate, 139
    cavity preparation for silicate, 139
      class one, 139
      class two, 139
      class three, 139
      class four, 143
      class five, 143
    defective enamel pits, 143
    pressure method, 143
      technic of, 143
    impression, 144
    making mix, 144
    filling cavity, mallet method, 145
    summary, fundamentals for durability, 152
Silver-tin alloy, aging of, 225
Sordes, 36
  removal of, 38
Sprue in relation to casting, 202
  wire, placing of, 197
Stains on teeth, 36
Step in class four cavities, 109, 157
  in class two cavities, 83
  in resistance form, 65
  omission of, 81
Synthetic porcelain, 136
Systemic treatment for hypersensitive dentine, 55

T

Tic douloureux, 26
Tin amalgam, reaction expansion of, 226
  and gold combination filling, 258
  in alloy, contraction facilitated by, 224
Toilet of cavity, Chapter XIV, 70
    definition, 70
    how best accomplished, 70
    white enamel margins, 70
    disks and strips, how used, 70
    disinfection and pulp protection, 71
    leaks in rubber dam, 71
    time between cavity preparation and filling, 71
    conclusion, 71
Toothbrush, proper use of, 38

V

Vital pulp, protection of, 324 (*See also* Protection of vital pulp)
  tooth and endodontia, 411
    defined, 321

W

Walls, enamel, finishing, 69
  of cavity, defined, 43
Wax pattern for gold inlay, 195

X

X-ray before partial pulpectomy, 353
  before pulpectomy, 330
  in preventive dentistry, 29
  in treating putrescence, 362, 366, 368, 370, 373, 376

Z

Zinc as pulp capping, 328
  chloride as remedy for hypersensitive dentine, 54
  in amalgam filling technic, 213
  in cement fillings, 251

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